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JOURNAL OF SCIENCE

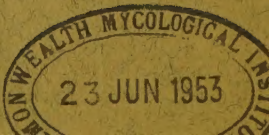
A Quarterly of Research



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ABSTRACTS OF DOCTORAL DISSERTATIONS

ACCEPTED JULY 1, 1951 — JUNE 30, 1952

These abstracts are arranged in alphabetical order by names of the authors. The first page of each abstract carries also the serial number of the dissertation, the date of acceptance of the thesis by the Graduate College, the name of the chairman of the student's committee, the degrees held by the author, and the candidate's academic position and relationship (if any) to the several research institutes of Iowa State College.

The following summaries and indices may prove helpful to those interested in tabulations and to those who wish to examine groups of abstracts of theses in the same or related fields.

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3. INDEX TO THESES BY RESEARCH INSTITUTES THAT PROVIDED RESEARCH FACILITIES. A graduate school can function only where there are adequate opportunities for research. The existence on the campus of Iowa State College of six research institutes well integrated into the college programs is in large measure responsible for the growth of the graduate work. These institutes have frequently assumed the responsibility of providing the research facilities necessary for the doctoral candidates in their respective fields. It is obvious that these institutes carry on a significant fraction of their researches by use of workers who are in a sense apprentices in research. Under the name of each institute is given the total number of theses for which research facilities were afforded, and an alphabetical list of the authors of sponsored theses.

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ACTION OF CERTAIN ORGANIC COMPOUNDS AS SYSTEMIC INSECTICIDES¹

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Department of Zoology and Entomology

The concept of controlling insects by rendering the plant repellent or poisonous is not new. However, not until recently was the idea employed successfully. This present investigation was undertaken for the purpose of developing an effective systemic insecticide. The study included five main groups of compounds: alkylamines, quarternary ammonium salts, aromatic carboxylic acid and phenolic compounds, N-heterocyclic compounds, and phosphorus-containing compounds. In addition, a large number of compounds of diverse structure from other chemical groups were tested.

The pea aphid, *Macrosiphum pisi* (klth.), and Blue Bantam pea were the primary test subjects. Many of the compounds were also tested against the two-spotted spider mite, *Tetranychus bimaculatus* Harvey, on Tendergreen green bean and other insects and plants as they became available. The substances were applied by the spray and/or soil treatment methods. A description of the techniques used is given in detail.

A summary table is presented showing the results of 136 organic substances (26 alkylamines, 19 quarternary ammonium compounds, 28 aromatic carboxylic acid and phenolic compounds, 25 N-heterocyclic compounds, 12 phosphorus compounds, and 26 compounds selected from diverse chemical groups) which were investigated as systemic insecticides. Eight chemicals found to possess systemic insecticidal properties against the pea aphid were: tetramethylammonium bromide, chloride, iodide, and hydroxide; 2-(α -hydroxypropyl) pyridine; octylheptamethylpyrophosphoramide; dodecylheptamethylpyrophosphoramide; and ethyl carbamate. Some compounds were more readily ab-

sorbed through the leaves than through the roots, while the reverse was true of other compounds. Several systemic insecticides were found to be phytotoxic when applied as a spray, but they were injurious to plants when applied to the soil around the plants.

The tetramethylammonium compounds represent a group heretofore not reported as showing systemic insecticidal activity against aphids. The bromide and chloride compounds were more effective than the iodide or hydroxide and much less phytotoxic. Tetramethylammonium chloride was more phytotoxic than the bromide, especially to beans. All of the compounds were more effective when applied as sprays than as soil treatments, although both methods can be used for aphid control. None of the quarternary ammonium compounds appeared to hold promise as a systemic miticide.

2-(α -Hydroxypropyl) pyridine exhibited systemic toxicity to aphids only when it was administered as a soil treatment. Mites were not affected. Some phytotoxicity was associated with the compound.

Several derivatives of octamethylpyrophosphoramide (OMPA), i.e., octylheptamethylpyrophosphoramide (OHPA) and dodecylheptamethylpyrophosphoramide (DHPA), were effective systemic insecticides. Plant injury resulted from spray formulations, but there was no injury to plants when the materials were applied to the soil. The order of relative insect toxicity was: OMPA > OHPA >> DHPA. Hydrolyzed components of these compounds were found to be systemically inactive against aphids.

Ethyl carbamate applied as a soil treatment rendered pea plants repellent to the pea aphid. However, the compound was also somewhat toxic to plants.

An extensive review of literature of the methods and compounds employed as systemic insecticides is presented and some of the theoretical aspects of the experimental results are discussed in the thesis.

- 1 a. Chairman of Committee, Chas. H. Richardson, Dept. of Zoology and Entomology.
b. Doctoral Thesis No. 1152. Submitted March 15, 1951.
- 2 a. B.S., Rutgers University, New Brunswick, N.J., 1940.
M.S., *ibid.*, 1942.
b. Associate, Agricultural Experiment Station.

METALLURGY OF THE RARE EARTHS WITH PARTICULAR EMPHASIS ON CERIUM¹

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Institute for Atomic Research and the Department of Chemistry

The general method for the preparation of cerium metal by the metallothermic process as first perfected at this laboratory was successfully applied for the preparation of neodymium and praseodymium metal. The metals were formed by the reduction of the anhydrous trichlorides of the rare earths, with an auxiliary oxidant of iodine in the ratio of 0.63 moles of iodine to one mole of the chloride, with calcium in 10 per cent excess; the iodine provided the excess heat required to melt completely the reaction products and thereby to permit the metal to separate. The reductions were carried out in a steel bomb lined with a sintered lime crucible. In the production of the rare earth metals, optimum yields were obtained by reducing charges of chloride consisting of 300 gm. or more with the corresponding amounts of iodine and calcium; however, for experimental reductions smaller charges were used. In the present work, 4 kg. of pure cerium metal, 1.8 kg. of didymium metal (80 per cent Nd, 10 per cent Sm, 8 per cent Pr, and 2 per cent other rare earths), 500 gm. of neodymium metal, and 33 gm. of praseodymium metal were prepared. The preparation of these metals by the reduction method was completely reliable with no failures in any reduction attempt. An average of the yields obtained for each of these metals is: 90.4 per cent for cerium, 91 per cent for neodymium, 76 per cent for praseodymium (on small scale where yields are low), and 83.5 per cent for didymium. The ingot metal produced in the reduction is well formed, with smooth sides and top, and is free of occluded slag. Calcium and magnesium are introduced as impurities to the extent of 1 or 2 per cent by this preparation method, but are removed by vacuum casting at high temperatures.

An ingot of impure yttrium (70 per cent Y, 18 per cent Nd, 10 per cent Sm, and

2 per cent Gd) was prepared by the same process; however, the procedure did not yield a metal ingot by the reduction of the chloride of more pure yttrium (90 per cent Y, 6 per cent Dy, 2 per cent Gd, and 1.5 per cent Sm). The failure is attributed to the high melting point of yttrium which prevented the fusion and, consequently, the collection of the metal.

An extrapolation of this method to the preparation of samarium metal from the halide was unsuccessful. No metal could be obtained by the reduction of the trichloride, trifluoride, or tri-iodide of samarium by calcium, with either iodine or potassium chlorate as "boosters." A small amount of a samarium-calcium alloy was prepared by the reduction of samarium dichloride by calcium but could not be recovered for recasting. A zinc alloy of samarium was produced and separated in low yields by the co-reduction of samarium trichloride or trifluoride and zinc chloride by calcium. The reactivity and brittleness of the alloy produced made it quite difficult to remove the metal from the slag; however, 10 gm. of the alloy were recovered and recast to yield 2 gm. of a samarium-rich metal containing greater than 50 per cent samarium.

Magnesium oxide, calcium oxide, and beryllium oxide were tested as crucible materials in studies on the purification of the metals; of these, magnesium oxide was most resistant to attack by the molten metals. By casting in crucibles of this oxide, metals of high purity could be obtained. The metals, molybdenum and tantalum, were also investigated as crucible materials. Cerium, heated to 1700°C. in tantalum and to 1400°C. in molybdenum, did not dissolve detectable amounts of the crucible material.

The melting points and densities of cerium and neodymium metal were determined. The density of cerium metal containing 0.1 per cent calcium is 6.747 gm. per cc., a value which is 0.04 gm. per cc. less than the theoretical density reported from crystallographic data. The hardness of the metal is 25 on the Knoop

- 1 a. Chairman of Committee, F. H. Spedding, Institute for Atomic Research and the Dept. of Chemistry.
- b. Doctoral Thesis No. 936. Submitted December 18, 1948.
- 2 a. B.S., Iowa State College, Ames, Iowa, 1941.
- b. Assistant, Institute for Atomic Research.

Hardness Scale, which is slightly below the reported values of this property. The workability of the metal is limited by the oxide inclusions introduced during recasting. The melting point of cerium, containing 0.1 to 0.2 per cent calcium and 0.05 to 0.2 per cent magnesium, was found to be $793 \pm 5^\circ\text{C}$. A solid transformation occurred at $703 \pm 10^\circ\text{C}$.

Neodymium metal with 0.5 per cent cerium and 1 per cent magnesium has a density of 6.999 which is equal to the theoretical density reported from X-ray

The vapor pressure of cerium metal, from 10^{-3} to 10^{-2} mm. of Hg, was determined in the temperature range from 1460 to 1720°K . by a modification of Knudsen's effusion method in which the amount of metal condensed on the target was measured by use of radioactive cerium tracer. The vapor pressure at each temperature was calculated from the temperature of the sample, the geometry of the system, and the quantity of metal condensed on the target. The relation between the vapor pressure of the cerium and the temperature was found to be:

$$\log_{10} P_{(\text{mm. Hg})} = - \frac{23,400 \pm 440}{T} + 11.58 \pm 0.27.$$

data. The melting point of metal of this purity is $820 \pm 10^\circ\text{C}$.; no solid transformations were observed.

From this equation, the calculated heat of vaporization is 107.7 ± 2.0 kilocalories, and the calculated boiling point at atmospheric pressure is $2690 \pm 70^\circ\text{K}$.

GOOD AND CHOICE BEEF ROUNDS: EFFECT OF EXTENT OF COOKING ON PALATABILITY AND EDIBLE PORTION¹

PEARL JACKSON ALDRICH²

Department of Foods and Nutrition

On the basis of palatability and edible portion cost, nine cuts from U. S. Good grade beef round were compared with the corresponding cuts from U. S. Choice grade round. Grade designations throughout this study refer to the new federal specifications for grading of beef which became effective on January 1, 1951. The second phase of the investigation was concerned with the determination of changes in palatability and edible portion cost which occurred in meats during an hour of continued cooking after cuts reached an internal temperature of 90°C .

The adductor, rectus femoris, semitendinosus, vastus lateralis, semimembranosus, and biceps femoris were dissected from 2 pairs of U. S. Choice and 2 pairs of U. S. Good beef rounds and were trimmed to obtain pot roasts as similar in size and shape as possible. The cuts, wrapped in heavy locker cellophane, were

frozen at -34.4°C . and stored at -23.3°C . until the time of defrosting just prior to cooking.

The cuts were cooked by pairs in covered Dutch ovens within gas ovens at a constant temperature of 150°C . until the pot roasts reached an internal temperature of 90°C . At this point all the pot roasts were checked for total cooking weight loss, volume and dimensional losses, and amount of drippings. One pot roast of each pair was then returned to the 150°C . oven and cooked an additional hour. The same objective measurements were obtained for these cuts at the end of the extra hour.

Samples were scored by a panel of four experienced judges using a score range of 0 to 10 for aroma, flavor, appearance, texture, tenderness, and juiciness. Objective methods were also used for determining tenderness and juiciness. Very high correlations were found between the shear force readings and the tenderness scores for both grades of meat prepared by both methods. High correlation was also found between the juiciness scores and percentage of press fluid for both grades of beef cooked to an internal temperature of 90°C .

- 1 a. Chairman of Committee, Belle Lowe. Dept. of Foods and Nutrition.
b. Doctoral Thesis No. 1235. Submitted December 12, 1951.
- 2 a. B.S., Purdue University, Lafayette, Indiana, 1939.
M.S., *ibid.*, 1940.

but no correlation was found between the subjective and the objective methods for determining juiciness of pot roasts which were cooked beyond 90°C.

The average palatability scores of the judges indicated no preference between Good and Choice grades for aroma, flavor, tenderness, juiciness, or texture. Scores for appearance were slightly in favor of Choice grade cooked by both methods. Objective tests, based on shearing and pressometer methods, showed Choice cuts, cooked an additional hour after the internal temperature reached 90°C., were slightly more juicy and tender than the corresponding Good cuts cooked in the same way.

The additional hour of cooking after the cuts reached an internal temperature of 90°C. resulted in marked deterioration of palatability in both grades of beef. Development of strong, sulfury odors and flavors, decrease of juiciness, and loss in attractiveness of appearance were noted by the judges. A slight increase in tenderness, determined both by objective and subjective measurements, was noted in Good and Choice grades when the cuts were cooked beyond 90°C. internal temperature. Statistical analysis showed that the cooking treatment was an important source of variance in the scores of all palatability factors tested except texture.

The cost of the edible portion was calculated for Choice and Good grade cuts prepared according to the two cooking

methods. The weight of the uncooked cuts, allowances for bone, waste, and edible trim, and cooking weight losses were considered in determining the cost of the cooked meat. The total cost of edible portion included the cost of the cooked meat and the cost of the fuel used in preparation. On this basis, a 2.5-ounce portion of the Good grade cuts cooked to 90°C. internal temperature cost \$0.2229, and a similar portion of Choice grade cuts cost \$0.2343. For the pot roasts cooked an hour at 150°C. after they reached an internal temperature of 90°C., the portion cost from Good grade cuts was \$0.2406 and from Choice grade cuts was \$0.2461.

From the findings of this study it appears that eating quality of U. S. Good beef rounds cooked by moist heat compares favorably with that of Choice beef rounds prepared in the same way. There was no appreciable difference in the cooking losses between the two grades of beef cooked by the two methods. Since the market price of Good grade beef rounds is usually slightly lower than that for Choice grade, it seems to offer a possibility for some savings in purchasing.

It was apparent from this study also that cooking beef pot roasts for an hour after they had reached 90°C. internal temperature resulted in loss of eating quality, increase in cooking losses, and increase in edible portion cost in both grades of beef.

RELATIONSHIP BETWEEN THE STRAINS IN MEMBERS AND THE END CONNECTIONS IN AN ALUMINUM TRUSSED SPACE-FRAME TOWER¹

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Department of Civil Engineering

The objective of this investigation was to study the effect of end connections on the behavior of single-angle compression and tension members in an aluminum space-frame tower, and then, on the basis of the results of this study, to develop practical design methods which more

closely approximate the actual behavior of these members than those now used in structural design.

Three members of the tower were selected, and each of these members was tested in compression and tension. The test members were all unequal leg single-angle members attached to the structure by gusset plates at each end. Observations were first made on the members while they were in their normal positions in the tower. Then, each member was removed and observations were made in the testing machine with four controlled end condi-

1 a. Chairman of Committee, Frank Kerekes, Dept. of Civil Engineering.

b. Doctoral Thesis No. 1210. Submitted August 22, 1951.

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tions. The four end conditions used were:

1. Rigid-fixed
2. Hinged parallel to the gusset plates
3. Hinged normal to the gusset plates
4. Hinged both parallel and normal to the gusset plates.

In all of these tests, strain measurements were made at numerous predetermined critical points with SR-4 electric strain gages. The strain measurements of the members in the tower were compared with those of the corresponding members tested individually in the testing machine. This comparison provided a reliable means for establishing the particular structural behavior of the members in the tower on the basis of the controlled conditions in the testing machine.

The conclusions defining the structural behavior of these single-angle members in the tower are:

1. For the type of gusset plate used in this investigation, the end of the plate attached to the structure closely approaches the rigid-fixed condition for bending about the axes in the plane of, and perpendicular to the plane of, the gusset plate.
2. Practically all of the bending of a single-angle compression or tension member throughout its length develops about the axis parallel to the plane of its gusset plates.

By taking into account the elastic behavior as stated in the foregoing conclusions, mathematical analyses based on fundamental principles were made for both compression and tension members of the type tested in this investigation. These derived equations were verified experimentally by comparison with testing machine results which closely satisfied the assumptions on which the equations were based. The equations developed are of value for theoretical investigations, determination of limits, and development of practical methods of design. However, they are of less direct value to the practical designer.

The conclusions relating to controlling

items of design, such as inflection points, effective length, and limits of eccentricity, are:

1. The points of inflection at the two ends of a compression or tension member, for bending about an axis parallel to the plane of the gusset plates, are located:
 - a. Laterally, between the limits of the axes of bending of the angle and the gusset plates
 - b. Longitudinally, at the centroids of the bolt patterns at each end of the angle member.
2. The effective length of a compression or tension member is the distance between the points of inflection at the two ends of the member as indicated in 1.
3. When the effective length of the member and the limit of the eccentricity of the primary load are established, as stated in these conclusions, the rational formulas in present use for analyzing eccentrically loaded compression members yield results closely approximating those observed in this study.
4. When the effective length is established, as stated in these conclusions, Euler's well-known formula can be used to compute the critical load for the angle member.
5. When the limit of eccentricity, e , of the primary load is established, as stated in these conclusions, a tension member can be analyzed as an eccentrically loaded hinged-end member by using the expression $P/A \pm Mc/I$, where $M = Pe$.

All of the conclusions for primary elastic action resulting from these experimental and theoretical investigations are applicable to the type of single-angle member tested and the trussed space-frame tower type of structure used in this investigation. All of these conclusions are based on loads which do not produce stresses beyond the elastic limit of the material. In addition, for compression members the loads do not exceed the critical loads for the angles or the gusset plates.

FIRM-HOUSEHOLD INTERDEPENDENCE ON LOW INCOME FARMS, WITH PARTICULAR EMPHASIS ON PRODUCTION DECISIONS, CAPITAL ACCUMULATION, AND RESEARCH METHODOLOGY¹

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The problem in this study was to determine the causes for a lag in economic progress exhibited by low income farm areas in American agriculture. The analysis was oriented about the individual family in a given institutional setting. The socio-psychological theory of human behavior, accompanied by the writer's knowledge of the social setting in low income farm areas, provided a basis for development of the hypothesis and deductions therefrom on low income farmer use of resources. The hypothesis was not tested with quantitative empirical data. Secondary data were used as a guide in the theoretical development.

The assumptions for this study were: (1) individual farmers behave rationally but in a subjective sense; (2) farm families seek a maximum attainment of subjective ends; and (3) farm family ends are dependent upon (a) the physical environment and means for production, and (b) the values of other individuals in the culture. These assumptions were derived from elements of human behavior set forth in social science literature, particularly from psychology, social psychology, and cultural anthropology. Habit and custom were considered a category of subjective rationality of crucial importance in the construction of the hypothesis. These assumptions contradicted two postulates of contemporary static economic theory. The underlying assumptions of economic theory were (1) rational pursuit of maximum profits by individuals and firms, and (2) independence of firm and household economic variables.

The hypothesis developed from these assumptions was as follows: The cultural and physical environments in low income farm areas have influenced the values of

individual families to the extent that subjective satisfaction with outcomes in production was attained at a low level of efficiency in resource use. Subjective satisfaction with current or anticipated future production outcomes in a low income farm area discouraged individual family consideration of alternative production pursuits in the same cultural environment or in other cultures. Subjective satisfaction or equilibrium corresponded to a space in a multi-dimensional production surface or a range of outcomes in a plane; within this space or range, automatic behavior brought about by habit and custom prevailed. The high degree of homogeneity in values (ends) among individual families in low income farm areas deterred individual initiative and aspirations in productive activity. Thus, the lag in economic progress in low income farm areas was ascribed to the value pattern created and maintained by individual members of the culture.

Two categories of deductions were made from the hypothesis. The first category dealt with entrepreneurial decision-making. The second was an extension of the first group to include time as a variable. The life cycle of the family provided an analytical guide in the development of the second phase of the theory. The deductions were directed toward specific aspects of interdependence in farm production and family consumption.

The major deductions on low income farm entrepreneur decision-making were:

1. The values (ends) of the entrepreneur provide the basis for appraising current outcomes. A change in values can cause a dissatisfaction with production outcomes formerly considered satisfactory.
2. Entrepreneurial action in changing resource or factor combinations in production is induced by outcomes outside the range of subjective equilibrium. A state of inaction prevails when outcomes

1 a. Chairman of Committee, Earl O. Heady, Dept. of Economics and Sociology.

b. Doctoral Thesis No. 1247. Submitted February 20, 1952.

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occur within the range of subjective equilibrium.

3. The action taken to attain a subjective equilibrium is limited by the values of the entrepreneur, his perception (knowledge), and current input and product combinations. The rigidity in the asset organization of low income farms, associated with a fixed labor supply and low liquidity, is the most important limitation to the choice of alternatives in attaining higher outcomes.

The introduction of time as a variable in individual farmer behavior facilitated an identification of cyclical patterns in production and consumption. Production and consumption increased to a maximum near the middle of the family cycle, then declined. The family labor supply increase and decrease with family growth and decline were the major causal elements in the production and consumption cycles. Another factor influencing the cyclical

patterns was changes in values. Farmer decision-making over the cycle was influenced by changes in the rate of subjective discounting. Higher discounting occurred with an advance in the stage of the family cycle. The pattern of subjective discounting resulted in an accumulation followed by a stage of decumulation in capital assets.

A hypothesis on firm-household interdependence can be tested with quantitative data by testing deductions from the hypothesis relating to the economic effects of subjective values that conflict with the ends of society. The existence of interdependence in production and consumption limits the usefulness of research based exclusively on profit maximization principles as decision-making guides to low income farmers. A more useful approach in farm management research would be an orientation to problems which are common to both the individuals and society.

THE CRYSTAL STRUCTURES OF SOME THORIUM AND URANIUM COMPOUNDS¹

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The Structure of the U₂M Compounds

Isostructural compounds with the composition U₂M (where M = Mn, Fe, Co, and Ni) have been found and the structure determined. Single crystals, examined by the rotation, oscillation, Laue, and Weissenberg methods, exhibited the diffraction symmetry D_{2h} — 4/mmm. The unit cell dimensions of the body-centered tetragonal compounds are for U₂Mn, $a = 10.29$ Å., $c = 5.24$ Å.; for U₂Fe, $a = 10.31$ Å., $c = 5.24$ Å.; for U₂Co, $a = 10.36$ Å., $c = 5.21$ Å.; and for U₂Ni, $a = 10.37$ Å., $c = 5.21$ Å. There are four U₂M in a unit cell.

The general absences which were observed other than those due to body-centering are (0*kl*) with *k* odd and *l* odd. Since all the space groups which satisfy these intensity requirements and possess appropriate positions for the atoms have the same structure factor for (*h**k*0) reflections, the approximate positions for the uranium atoms were found by plotting the F values for the very strong reflections and for the absent reflections. These positions were further refined by the Fourier method using the (*h**k*0) data. The *z* parameters were chosen by examination of the (00*l*) data, but because of the effect of absorption on the intensities, the determination of the *z* parameter is uncertain. The final uranium positions are described by space group D_{2h}¹⁸ with

The possible variations of the *z* parameter are permitted in D₂⁹ and D_{2d}¹⁰.

The application of Pauling's valence and radii rules led to valences of ~ 5.4 for uranium and 4.5 for the transition metal atom. The zone bounded by the planes due to (600) and (002) contains the proper number of electrons if Hume-Rothery's valences are used. This is probably not very significant, however.

The Structure of the Th₂M₃ Compounds

The Th₂M₃ compounds (where M = Fe, Co, and Ni) crystallize with a hexagonal unit cell whose dimensions are for Th₂Fe₃, $a = 9.85$ Å., $c = 6.15$ Å.; for Th₂Co₃, $a = 9.83$ Å., $c = 6.17$ Å.; and for Th₂Ni₃, $a = 9.86$ Å., $c = 6.23$ Å. There are two Th₂M₃ in a unit cell. Single crystals, examined by rotation and Weissenberg methods, exhibited the diffraction symmetry of D_{6h}.

The approximate (*x*, *y*) positions of the thorium atoms were determined from a Patterson projection of the (*h**k*0) data. These positions were further refined by the Fourier method. The positions of the iron atoms were never clearly resolved and were determined mostly from spatial considerations. The determination of the *z* parameter was again subject to absorption errors. From the intensity data it was clear, however, that the atoms were ar-

(add 000, $\frac{1}{2}\frac{1}{2}\frac{1}{2}$ to all positions)

16 U at $\bar{x}y0$; $\bar{y}x0$; $\bar{y}x0$; $\bar{x}y\frac{1}{2}$; $\bar{x}y\frac{1}{2}$; $yx\frac{1}{2}$; $yx\frac{1}{2}$;

with $x = 0.2141$, $y = 0.1021$,

8 U at $x, \frac{1}{2} + x, 0$; $\bar{x}, \frac{1}{2} - x, 0$; $\frac{1}{2} + x, \bar{x}, 0$; $\frac{1}{2} - x, x, 0$;

4 M at $00\frac{1}{4}$; $00\frac{3}{4}$.

1 a. Chairman of Committee, R. E. Rundle, Dept. of Chemistry.

b. Doctoral Thesis No. 931. Submitted September 28, 1948.

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ranged in four layers, each approximately one-fourth of c apart. The final z parameters chosen are those which yield reasonable interatomic distances as well as satisfy the intensity data. These positions are

found in space group C_{2v}^4 with

- 2 Th at $\frac{1}{3}, \frac{2}{3}, z; \frac{2}{3}, \frac{1}{3}, \frac{1}{2} + z$; with $z = 0.06$
 6 Th at $x, 2x, z; 2x, x, z; x, x, z; \bar{x}, x, \frac{1}{2} + z; \bar{x}, 2x, \frac{1}{2} + z;$
 $2x, x, \frac{1}{2} + z$; with $x = 0.126$ and $z = 0.250$,
 6 Th at the same positions with $x = 0.544$ and $z = 0.03$,
 6 M at the same positions with $x = 0.815$ and $z = 0.31$.

Pauling's radii give the thorium atoms valences of approximately four and the transition metal atom ~ 4.5 . Again, a zone may be found which will contain the number of electrons expected using Pauling's valences. It is not clear, however, that this is the factor which determines the stability of the structure.

The Structures of U_2O_3 and U_3O_8

The uranium oxides other than UO_2 have been investigated previously and the existence of a one phase region extending from $UO_{2.65}$ to UO_3 has been reported, but only recently have structures been proposed for the oxides U_2O_3 and U_3O_8 . Single crystals of the oxide, U_2O_3 , which forms the lower limit of the one phase region have been found which have enabled a determination of its structure. Also

showed that the crystal had the diffraction symmetry of $D_{2h} - mmm$. The unit cell dimensions were found to be $a = 6.73$ Å., $b = 31.71$ Å., $c = 8.29$ Å. The pseudo cell dimensions, $a = 6.73$ Å., $b = 3.964$ Å., $c = 4.145$ Å., corresponded to the pseudo cell dimensions of U_3O_8 already reported. Be-

cause of the relative strength of reflections at high angles, it was assumed that the weak reflections requiring the large unit cell were due primarily to uranium atoms which were slightly removed from the ideal positions occupied in the pseudo unit of UO_3 .

Trial and error methods guided by Patterson projections determined approximate values of the x , y , and z parameters which were then refined by the Fourier method. Only space groups which had eight-fold positions were used. Two slightly different arrangements which gave very good agreement with the intensity data were found for the (x, y) coordinates of the atoms. The z parameters corresponding to these two arrangements are uncertain because of the absorption errors. The two possible structures are given below.

I in D_{2h}^{16}

- 8 U at $xyz; \bar{x}yz; \bar{x}, \bar{y}, \frac{1}{2} + z; x, y, \frac{1}{2} - z; \frac{1}{2} + x, \frac{1}{2} - y, \bar{z};$
 $\frac{1}{2} + x, \frac{1}{2} - y, \frac{1}{2} + z; \frac{1}{2} - x, \frac{1}{2} + y, \frac{1}{2} - z; \frac{1}{2} - x, \frac{1}{2} + y, z;$
 with $x = 0.2825, y = 0.0352, z = 0.013$,
 8 U in the same positions with $x = 0.745, y = 0.092, z = 0.993$,
 8 U in the same positions with $x = 0.2067, y = 0.1546, z = 0.995$,
 8 U in the same positions with $x = 0.745, y = 0.2227, z = 0.016$.

II in D_{2h}^5

- 8 U at $xyz; \bar{x}yz; \bar{x}yz; \bar{x}yz; x, \frac{1}{2} - y, z; \bar{x}, \frac{1}{2} + y, \bar{z}; x, \frac{1}{2} - y, \bar{z};$
 $\bar{x}, \frac{1}{2} + y, z$; with $x = 0.539, y = 0.0591, z = 0.259$,
 8 U in the same positions with $x = 0.988, y = 0.1295, z = 0.244$,
 8 U in the same positions with $x = 0.505, y = 0.1841, z = 0.238$,
 4 U at $x\frac{1}{4}z; x\frac{1}{4}z; \bar{x}, \frac{3}{4}, z; \bar{x}, \frac{3}{4}, \bar{z}$; with $x = 0.047$ and $z = 0.265$,
 4 U at $00z; 00z; 0\frac{1}{2}z; 0\frac{1}{2}z$; with $z = 0.220$.

powder diagrams of U_2O_3 have indicated the need for a larger unit cell than has been reported.

The Weissenberg diagrams of U_2O_3

If a unit cell of the same dimensions as U_2O_3 is chosen in the UO_3 structure, then only the symmetry of C_{2h} or lower is possible. Although the uranium positions may be described by orthorhombic space

groups, the oxygen positions must be described by monoclinic space groups. If only a slight change has taken place, the oxygen atom positions in U_2O_5 may also be described by monoclinic space groups.

Space group C_{2h}^2 describes the uranium positions as in D_{2h}^5 (with suitable parameters) and allows the oxygen positions to be varied from their positions in UO_3 .

The unit cell of U_2O_5 is made up of three orthorhombic cells of UO_3 (less two oxygen atoms) stacked in the b direction. All the reflections which were observed were of the type $(hk0)$ with $h + k$ equal to $2n$. The intensity data indicated the presence of both an x and y parameter for the uranium positions; hence, only space group

C_{2v}^{14} has the required positoins. The uranium atoms were found to be in the following positions:

2 U at $x00$ with $x = 0$,

4 U at $xy0$; $\bar{xy}0$; with $x = 0.04$ and $y = 0.326$.

Rotation diagrams of U_2O_5 normal to (130) indicated an approximate tripling of the pseudo cell axis which might correspond to U_2O_5 (actually instead of weak first and second layer lines and a strong third layer line, the layer lines, 1, 5, 6, 10, 11, 15, 17, etc. were weak and 16 and 32 strong). This might indicate that the cells were chosen at a rotation of approximately 60° .

The location of missing oxygen atoms from the UO_3 arrangement in U_2O_5 and U_3O_8 is difficult. Some of the uranyl oxygens are undoubtedly gone, however. The number of additional vacancies cannot be decided further.

A New Method for Determining X-Ray Intensities

A new method for determining the intensities of X-ray reflections from the record on photographic film has been developed which involves the radioactive toning of the film. Upon considering the various toning and intensifying processes and the isotopes now available, the cobalt-ferricyanide toning process seemed to be most promising. An investigation of the toning conditions disclosed that the two step process, using a ferricyanide bleach (5 per cent $K_3Fe(CN)_6$ plus 10 drops of NH_4OH per 100 ml. of water) and a radioactive toner of cobalt bromide (0.04 g. Co in 100 ml. water, 1.2 millicuries of activity), was suitable. The films, conventionally developed, fixed, washed, and dried, are soaked thirty minutes in water, placed in

(add 000, $\frac{1}{2}\frac{1}{2}0$ to all positions)

the bleach for at least thirty minutes, washed in running water for an hour, toned in $CoBr_2$ for at least thirty minutes, placed in several beakers of water for several hours to dilute the occluded and absorbed activity, washed in running water, and dried. The spots are punched from the film base and counted using a Victoreen Geiger-Müller counter.

The method has been tested on anthracene crystals and has been found to give results accurate to approximately 5 per cent. The intensity of a spot can be determined in two to ten minutes, depending on the size of the spot and its intensity.

FUNCTIONAL PROPERTIES OF EGG WHITE AS INFLUENCED BY ATOMIZATION AND DRYING¹

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A study was made to determine the limitations of spray drying as applied to

egg white. A meringue-type whip test was employed in following the changes in functional properties brought about by spray drying.

New surface formation which takes place in the atomization of egg white was studied by forming surfaces on a porcelain cylinder revolving through the liquid

¹ a. Chairmen of Committee, G. F. Stewart and Robert Tischer, Dept. of Food Technology.
b. Doctoral Thesis No. 1197. Submitted July 20, 1951.

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product. Formation of new surfaces was found to be detrimental to beating power of egg white. For the same quantity of surface formed, more damage was caused when high rates of surface formation were used.

A horizontal type spray drier was used to study the effects of atomization and spray drying. Three different types of atomizing devices were used: (1) internal mixing, two-fluid nozzle, (2) external mixing, two-fluid nozzle, and (3) special external mixing, two-fluid nozzle which effected the formation and atomization of foam. The former (1) was found to be the most detrimental, and the latter (3) the least detrimental to the beating properties of egg white. The differences found between the atomization devices are thought to be related to the rate of surface formation. For the internal and external nozzles, less destruction was imparted at lower air atomization pressures. Little, if any, additional deterioration was found to be caused by drying at the tempera-

tures (55-65°C. exhaust) used in this investigation.

Differences were noted in the type of egg white atomized and spray dried. Fresh egg white was less susceptible to deterioration than the commercial frozen egg white used in this study.

Fermentation by *Aerobacter aerogenes* did not alter changes brought about by atomization and spray drying. Blended thick white showed no more susceptibility to damage by spray drying and surface formation than did thin egg white. A higher beating power was noted in products produced from egg white atomized or spray dried at a pH between 7 and 8 than at a higher or lower pH.

Most of the added substances studied (sugars, salts, and surface-active agents) showed little promise in reducing the deterioration in egg white caused by spray drying.

Reconstituted spray dried egg white which had stood at 2°C. for 10 days showed improvement in beating power.

SHORT-LIVED SYNCHROTRON-INDUCED RADIOACTIVITIES¹

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The use of a scintillation spectrometer for measurement of the energy distribution and half-life of short-lived beta-emitters is described. The instrumentation is especially suited for use with radioactivities of low intensity resulting from photonuclear reactions produced by the Iowa State College 70-Mev synchrotron. Such activities are unsuited for study with a conventional magnetic spectrometer of small solid angle, particularly if the activities are short-lived, but may readily be analyzed with a scintillation spectrometer, for which the solid angle of acceptance is close to 50 per cent.

The high energies of the beta-spectra associated with short-lived radioactivities permit the attainment, for energies above 3 Mev, of an instrumental resolution better than 10 per cent. Suitable recording de-

vices provide information concerning both the energy spectrum and the half-life. To insure proper operation of the equipment, preliminary studies were made using radioactive materials for which the characteristics of the beta-spectra were well known. These tests yielded endpoints in essential agreement with previous magnetic spectrometer work and also indicated that the first-forbidden character of the yttrium⁹⁰ decay could be detected.

The short-lived radioactivities studied with the scintillation spectrometer may be divided into two groups. In the first are those with half-lives of the order of minutes while in the second are those of the order of seconds. The first group consisted of praseodymium¹⁴⁰ and iron⁵⁵. Endpoints of 2.35 ± 0.10 Mev and 2.60 ± 0.10 Mev respectively were obtained for these activities.

Those nuclei investigated in the second group all have one more proton than neutron. On decaying, a positron is emitted. The data concerning these nuclei may be used as a check of the Wigner

1 a. Chairman of Committee, L. Jackson Laslett, Dept. of Physics.

b. Doctoral Thesis No. 1189. Submitted July 13, 1951.

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theory,³ which asserts that, due to the existing symmetry, the Coulomb repulsion energy accounts for the entire energy difference between the two ground states, provided the positron emission is between such states. A reasonable confirmation of the theory is shown for these data.

³ E. Wigner, *Phys. Rev.*, 51, 947 (1937).

The data also appear to obey the predicted approximate proportionality between the inverse of the fifth root of the half-life and the endpoint energy of the positron spectrum. The endpoints and half-lives obtained are shown in Table 1; ft-values obtained appear to support the Gamow-Teller modification of the Fermi theory of beta-decay.

TABLE 1
DETERMINATIONS OF ENDPOINT, HALF-LIFE, AND FT-VALUES FOR $Z - N = 1$ NUCLEI

Nuclei	Endpoint (<i>Mev</i>)	Half-Life (<i>Seconds</i>)	ft (<i>Seconds</i>)
Na ²¹	2.53 ± 0.10	27 ± 4	4460 ± 1300
Mg ²³	2.99 ± 0.10	12.3 ± 0.4	4670 ± 800
Si ²⁷	3.48 ± 0.10	5.4 ± 0.4	3740 ± 700
S ³¹	4.06 ± 0.20	3.2 ± 0.3	4320 ± 1200
Cl ³³	4.43 ± 0.20	1.8 ± 0.1	3440 ± 900
K ³⁷	4.57 ± 0.20	1.2 ± 0.2	2700 ± 1000
Ca ³⁹	5.13 ± 0.20	1.1 ± 0.2	3990 ± 1300

PERIODIC ORBITS IN THE NEIGHBORHOOD OF LIBRATION POINTS IN CERTAIN ROTATING SYSTEMS¹

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The paper is concerned with the motion of a point mass m located in a space referred to a coordinate system xyz which rotates about the z axis with a constant angular velocity ω . In addition to the centrifugal and Coriolis forces associated with rotation, the point mass m is assumed to be acted upon by a force derivable from a particular potential function $\phi(x, y, z)$.

Matrix notation is used to derive the equations of motion of m by a transformation of Newton's equation of motion. The equations of motion thus obtained are

$$m \left(\frac{d^2x}{dt^2} - 2\omega \frac{dy}{dt} - \omega^2 x \right) = \frac{\partial \phi}{\partial x} \quad (1)$$

$$m \left(\frac{d^2y}{dt^2} + 2\omega \frac{dx}{dt} - \omega^2 y \right) = \frac{\partial \phi}{\partial y} \quad (2)$$

$$m \frac{d^2z}{dt^2} = \frac{\partial \phi}{\partial z} \quad (3)$$

These differential equations are non-linear unless the potential function ϕ belongs to a restricted class of functions.

A particular potential function giving a set of linear differential equations is illustrated by a problem in which the point mass m is connected to n fixed anchor points (x_i, y_i, z_i) by means of n linear springs, each of a particular stiffness k_i , where $i = 1, 2, 3, \dots, n$. It is shown that the resulting motion of m is the same as that which would occur if the entire system of springs and anchor points were replaced by an equivalent single spring attached to an equivalent single anchor point. Explicit solutions are obtained by use of the Laplace transformation.

Following this linear problem, the remainder of the paper concerns the motion

in the xy -plane of the point mass m when the potential ϕ is that due to certain distributions of Newtonian potential sources in the xy -plane. The substitutions $\tau = \omega t$, $r^2 = x^2 + y^2$, and

$$\Omega = \frac{r^2}{2} + \frac{\phi}{m\omega^2} \quad (4)$$

applied to Equations (1) and (2) yield

$$\ddot{x} - 2\dot{y} = \Omega_x \quad (5)$$

$$\ddot{y} + 2\dot{x} = \Omega_y \quad (6)$$

where the dot indicates differentiation with respect to τ and the subscript on Ω denotes partial differentiation with respect to the variable indicated. Points in the xy -plane, where $\Omega_x = \Omega_y = 0$, are known as libration points.

Due to the non-linear nature of the differential equations associated with the gravitational potential, the scope of the subsequent discussion is limited to a study of the motion of the point mass m in the neighborhood of a libration point. When placed at a libration point L , the point mass m may be considered to be in a state of equilibrium, since it will remain at L in the absence of disturbances from sources external to the system. The stability of this state of equilibrium is determined by the existence of stable infinitesimal orbits in the neighborhood of the libration point. The conditions for the existence of stable infinitesimal orbits about a libration point are obtained by approximating (5) and (6) by retaining only the linear terms in the series expan-

1 a. Chairman of Committee, J. J. L. Hinrichsen, Dept. of Mathematics.

b. Doctoral Thesis No. 1255. Submitted March 13, 1952.

2 a. B.S., Iowa State College, Ames, Iowa, 1949.

M.S., *ibid.*, 1950.

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sions about the libration point of Ω_x and Ω_y .

Necessary and sufficient conditions for stable infinitesimal orbits are shown to be

$$\Omega_{xx} + \Omega_{yy} - 4 < 0 \quad (7)$$

$$\Omega_{xx}\Omega_{yy} - \Omega_{xy}^2 > 0 \quad (8)$$

$$4(\Omega_{xx}\Omega_{yy} - \Omega_{xy}^2) < (\Omega_{xx} + \Omega_{yy} - 4)^2, \quad (9)$$

where the partial derivatives Ω_{xx} , Ω_{yy} , and Ω_{xy} are evaluated at the libration point.

Under a continuous variation of the geometry of a potential-producing system, the above stability conditions may change. This behavior is illustrated in three different systems which are examined with regard to the stability criterion. The first of these is the well-known restricted problem of three bodies; the second is a restricted problem of four bodies; and the third is a problem of a point mass centered on a rotating, infinite rod.

While an orbit about a libration point may be unstable in the infinitesimal sense, it is possible that it could assume a stable state with finite dimensions. Conversely, while an infinitesimal orbit about a certain libration point may be stable, it is possible that it could become unstable if its dimensions were made finite. A study of these possibilities requires that higher order terms in the Ω_x and Ω_y expansions be retained.

The paper is concluded with a more extended study of the problem of a point mass centered on a rotating infinite rod,

following a method previously used by Pedersen³ in connection with the restricted problem of three bodies. The partial derivatives of Ω are approximated by the

first ten terms in their respective Taylor's series expansions about the libration point. The solutions, assumed to be periodic functions of time, are approximated by retaining the first seven terms in their respective Fourier expansions. The terms retained include those corresponding to the fundamental orbit frequency and its second and third harmonics. The Fourier coefficients are assumed to be such that those terms which correspond to the fundamental frequency are of the first order, while those corresponding to the second and third harmonics are of second and third order, respectively. The constant terms are assumed to be of the second order. Results showing the variation of the fundamental orbit frequency with orbit dimensions are obtained. The problem is concluded with the definition of a limiting orbit for which the Fourier coefficients are presented in tabular form.

- 3 Pedersen, Peder. *On the Periodic Orbits in the Neighborhood of the Triangular Equilibrium Points in the Restricted Problem of Three Bodies*. Monthly Notices of the Royal Astronomical Society, 94, No. 2: 167-185 (December 1933).

PURIFICATION AND CHARACTERIZATION OF FUNGAL ALPHA-AMYLASE¹

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The use of fungal agents in place of malt in the conversion of starchy mashers for alcohol fermentation has been clearly shown to result in higher yields of product. As a part of an effort to isolate the fungal enzymes involved in the conversion

process and to determine their individual roles in starch degradation, the purification of the alpha-amylases of *takadiastase* was undertaken.

The method of alpha-amylase purification devised by Underkofler and Roy (1) and successfully applied by them to submerged culture filtrates of *Aspergillus oryzae* failed to give comparable results with *takadiastase*. As a result, an investigation was made of the purification obtainable by precipitation with ammonium sulfate, ethanol, and acetone and by ad-

- 1 a. Chairman of Committee, L. A. Underkofler, Dept. of Chemistry.
- b. Doctoral Thesis No. 1268. Submitted May 27, 1952.
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- b. Assistant, Industrial Science Research Institute.

sorption on bentonite and starch. The progress of the purification was followed by means of the Sandstedt, Kneen, and Blish (2) procedure with the exception that beta-amylase was omitted in preparing the starch substrate. The unit (indicated by the symbol U) of enzyme activity thus obtained is equivalent to the amount of enzyme which hydrolyzes one gram of starch in one hour.

Ammonium sulfate at 0.70 saturation precipitated 88 per cent of the alpha-amylase of takadiastase, while at 0.60 saturation only 59 per cent of the enzyme precipitated and at 0.50 saturation no precipitate was obtained. Concentrations of ammonium sulfate higher than 0.70 saturation failed to give an increased yield of enzyme. Electrophoretic analysis of the precipitates obtained indicated that maximum purification was achieved on the first precipitation.

The solubility of alpha-amylase in ethanol solutions at pH 5.5 decreased gradually with increasing alcohol concentrations. Precipitation of the enzyme began at 56 per cent ethanol; 23 per cent of the activity was precipitated by 73 per cent ethanol, and in 90 per cent ethanol solution 67 per cent of the alpha-amylase had precipitated. On the other hand, alpha-amylase showed a sharp solubility gradient in acetone solution at pH 5.5 with 3.2 per cent of the activity precipitating in a 50 per cent solution, while 71 per cent of the activity was thrown out of solution by 60 per cent acetone. Further increases in acetone concentration caused very little additional precipitation, and concentrations as high as 90 per cent caused marked inactivation. Repeated acetone fractionations afforded little added purification.

Bentonite at the 4 per cent level adsorbed alpha-amylase and limit dextrinase to about the same extent in solutions of

pH 4.0-6.0. On the other hand, electrophoresis showed that bentonite adsorption for one hour at pH 4.2 eliminated a component of the system which was retained through both acetone and ammonium sulfate precipitations.

Adsorption of alpha-amylase by potato, corn, rice, and arrowroot starch from 40 per cent ethanol solutions at 0°C. was about equal if the original activity of the solution was 50 U/ml. However, in a solution containing only 5 U/ml. of alpha-amylase, rice starch adsorbed the enzyme most strongly, and the enzyme could be eluted with distilled water. Batchwise starch adsorption failed to separate alpha-amylase from limit dextrinase.

A procedure was developed in which a 2 per cent solution of takadiastase was first fractionated with acetone between 50 and 60 per cent concentration. The precipitate was then dissolved, adjusted to pH 4.2, the solution stirred for one hour with 4 per cent bentonite, and finally the enzyme was precipitated with ammonium sulfate at 0.75 saturation. The precipitate dissolved in a minimum quantity of water had an activity as high as 1260 U/ml.

The enzyme purified in this manner had a specific activity of 170 U/mg. N, a four-fold concentration over the original takadiastase, and an electrophoretic mobility of 6.59×10^{-5} cm.² sec.⁻¹ volt⁻¹ in phosphate buffer pH 7.5, ionic strength 0.20.

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DEVELOPMENT OF FUSED PHOSPHATE FERTILIZERS¹

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An investigation was undertaken to develop phosphate fertilizers by fusing phosphate rock with (a) langbeinite ($K_2SO_4 \cdot 2MgSO_4$), (b) magnesium or potassium sulfate, (c) mixtures of magnesium and potassium sulfate, and (d) other addition agents. Such fertilizers would have the advantage of containing plant nutrients other than phosphorus, e.g., magnesium and potassium, and would be especially suitable for soils deficient in these elements. In addition, the fused products would be basic and could be immediately bagged and shipped without further curing. The process would require neither critical sulfuric acid nor expensive phosphoric acid, as do the present acidulation processes, and might therefore be well adapted to the Midwest and many other localities.

In laboratory studies, fusions of a Florida rock phosphate with various addition agents were made in a small furnace constructed of high temperature insulating brick and fired with natural gas. The phosphate rock and various proportions of the addition agents were thoroughly mixed, and fused in a suitable crucible in the furnace. The molten product was quenched by pouring the melt into an aqueous cooling medium. The quenched product was dewatered, dried, and analyzed.

The major emphasis in the experimental work was upon fusions using langbeinite as an addition agent since it can be obtained in commercial quantities at a low cost. Fusion of this material in various proportions with phosphate rock gave products which showed maximum P_2O_5 availability when mixtures containing at least 70 per cent langbeinite were used. The P_2O_5 availability of the products from these mixtures was 96 per cent or greater. Typical fused product from a 70 per cent langbeinite mixture contained 14.6 per cent P_2O_5 , 11.4 per cent MgO, 11.6 per cent K_2O , and 1.6 per cent fluorine. The P_2O_5

availability was 98 per cent, according to the procedures of the Association of Official Agricultural Chemists. The water-soluble fraction, however, contained no P_2O_5 . Availabilities of MgO and K_2O were at least 95 per cent, using a hot water extraction as prescribed by the A.O.A.C. The product was chalk white, soft, and easily ground. Fusions of compositions below 50 per cent langbeinite could not be made successfully in the laboratory furnace because the temperatures required were above $2600^\circ F.$, which was the maximum obtainable in the furnace.

Fusion of magnesium sulfate and phosphate rock gave products of complete P_2O_5 availability when mixtures containing at least 75 per cent magnesium sulfate were used. The fusion products from mixtures of potassium sulfate and phosphate rock showed relatively low P_2O_5 availabilities however, being only 55 per cent when 90 per cent potassium sulfate was used in the charge.

A three-component study of the system $MgSO_4$ - K_2SO_4 -phosphate rock showed that high P_2O_5 availability was obtained when mixtures were fused whose compositions lay in an area on a triangular chart approximately bounded by the $MgSO_4$ apex and compositions containing 25-35 per cent $MgSO_4$ and various amounts of K_2SO_4 .

Other addition agents were also tested, including $MnSO_4$, $MgCl_2 \cdot 6H_2O$, cryolite, bauxite, potash spar, and zeolite. However, none of these could be fused successfully, because of transition to the oxide form, which was infusible at temperatures obtainable in the laboratory furnace.

It was found that aqueous quenching of the molten product gave the highest P_2O_5 availabilities. When non-aqueous quenching media such as air, steam, or organic solvents were used, lower availabilities were obtained.

A pilot plant was built and successfully operated, using langbeinite and phosphate rock, at a production rate of 100 to 150 pounds of fused product per hour. A vertical gas-fired shaft furnace was used with a chrome-plastic refractory hearth. No refractory corrosion was observed. There was no evidence of appreciable

1 a. Chairman of Committee, G. L. Bridger, Dept. of Chemical Engineering.

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loss of product by volatilization. The product was finely granulated by quenching sprays, and P_2O_5 availabilities as high as 95 per cent were obtained.

A cost estimate for a proposed 100 ton per day commercial plant, located in central Iowa, indicated a production cost of \$34.12 per ton of bagged product. As-

suming a selling price of \$38.88, based on the P_2O_5 and K_2O content only, the return on an estimated total investment of \$769,000 would be approximately 5.5 per cent. Because of the magnesium content of the product and its other special properties, it is likely that a higher price could be obtained in many localities.

ROLE OF COORDINATION COMPLEXES IN OXIDATION REACTIONS INVOLVING IONS¹

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Careful examination of the literature has revealed a number of reactions which have been studied for the purpose of proposing a mechanism. The reactions surveyed are: the trivalent manganese-oxalate reaction, the periodate oxidation of polyalcohols, chromic acid oxidation, the iodine-azide reaction, decomposition of thiosulfate ion, the persulfate-iodide reaction, the reduction of iron (III), cerate oxidation of organic compounds, sodium and potassium tungstate decomposition of hydrogen peroxide, oxidation of ferrous salts by nitric oxide, oxygen oxidation of tin (II), ferricyanide oxidation of nitrogen containing compounds, oxidation of acetone by selenious acid, copper (II) oxidation of oxide ion, copper (II) decomposition of hydrogen peroxide, and oxidation

of titanium (III) by iodine. Complex formation was proposed in all these reactions.

The cerate oxidation of meso-2,3 butanediol in perchlorate solutions was examined in detail. The experimental data were interpreted to indicate that cerate ion did not coordinate perchlorate ion but coordinated hydroxyl ion at low hydrogen ion concentration, and that di- and triglycolated cerate complexes were involved in the oxidation.

Evidence was presented that coordination of inert ions or molecules in solution may retard or hasten the over-all rate and that in some cases, coordination of an inert ion or molecule may be necessary for the reaction to occur.

The proposal was made that complex formation of oxidant with reductant is a necessary condition for the oxidation reaction to occur. It was shown in the interpretation of experimental data that a second order kinetics expression can be derived for a reaction which is actually a unimolecular disproportionation of an intermediate complex.

1 a. Chairman of Committee, F. R. Duke, Dept. of Chemistry.

b. Doctoral Thesis No. 1240. Submitted December 14, 1951.

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REACTIONS OF PHOSPHINE AND PHOSPHONIUM IODIDE¹

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Most of the chemistry of phosphine and phosphonium iodide was studied over fifty years ago. The present study is a review of some of the older studies and an extension of the usefulness of these two compounds as synthetic agents.

An improved procedure for the preparation of phosphonium iodide from a mixture of phosphorus-diphosphorus tetraiodide has been described. The total time required for the preparation has been substantially shortened over that of previous procedures and the attention required from the experimenter has been greatly reduced.

The action of phosphine on bromine in carbon tetrachloride (5-10 per cent solution by volume) will yield phosphorus (III) bromide in a pure form if the phosphine is added in slight excess of the stoichiometric amount. This can be readily determined by the decolorization of the bromine solution. The factors which must be controlled in this reaction are the concentration of the bromine solution and the rate of addition of the phosphine. The reaction must be carried out in an inert atmosphere. Phosphonium iodide was found to react with a carbon tetrachloride solution of bromine to form phosphorus (V) bromide.

Phosphonium iodide was found to react with a carbon disulfide solution of iodide to yield either diphosphorus tetraiodide or phosphorus (III) iodide depending on the ratio of the reactants. This procedure for the preparation of diphosphorus tetraiodide is recommended over other known preparations.

Antimony (III) phosphide was prepared by the action of phosphine on molten antimony (III) chloride. This compound is a reddish-brown solid insoluble in water but soluble in concentrated hydrochloric acid containing bromine.

Phosphine and disulfur dichloride were found to yield phosphorus (V) sulfide as one of the products, while phosphine and a large excess of a stoichiometric mixture of sulfur and bromine (S_2Br_2) were found to yield, as one product, thiophosphoryl bromide.

The preparation of primary lithium phosphide and primary magnesium phosphide was accomplished through the use of organometallic compounds. The organometallic compound was added dropwise to anhydrous diethyl ether in a reaction flask of special construction while a rapid stream of phosphine bubbled through the ether. The phosphides were washed with anhydrous diethyl ether, dried with a stream of nitrogen, transferred to a special flask for drying under vacuum, and then sampled for analysis. The procedure was applied to the preparation of the amides of lithium and magnesium. Further applications of this procedure and apparatus are suggested.

Phosphine gas passed over sodium hydride heated at approximately 150° yielded a product which was essentially primary sodium phosphide. Sodium analyses were higher and phosphorus analyses lower than calculated for primary sodium phosphide, which would indicate the presence of secondary and tertiary phosphides and possibly unreacted sodium hydride. A suggestion is given for improving the yield of the primary phosphide.

Phosphine was found to coordinate with aluminum bromide at room temperature to form aluminum bromide monophosphinate if the aluminum bromide was dissolved in benzene and then phosphine bubbled through the benzene solution. Addition of carbon disulfide to the benzene solution of the monophosphinate caused it to precipitate out. The formation of the monophosphinate had not been previously prepared at room temperature. Apparatus for drying and sampling is similar to that used for the primary phosphides of lithium and magnesium. The procedure was extended to the action of ammonia on a solution of aluminum bromide in benzene,

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b. Doctoral Thesis No. 1212. Submitted August 25, 1951.

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and pentammine aluminum bromide was formed. Further applications of this procedure are suggested.

The action of phosphonium iodide on acid chlorides was studied. Acetyl chloride and phosphonium iodide reacted at room temperature to yield an orange-colored solid whose properties and analysis would indicate that the compound might be ethylidynediphosphine hydriodide, $\text{CH}_3\text{C}(=\text{PH})\cdot\text{PH}_2\cdot\text{HI}$. Any structure as-

signed at present is highly speculative. More physical data, such as infrared spectra, are needed. Propionyl chloride and *n*-butyryl chloride under the same conditions yielded products whose analyses showed a phosphorus content higher and an iodine content lower than would be present in compounds which were analogous to the ethylidynediphosphine hydriodide.

DESOLVENTIZING AND TOASTING OF TRICHLOROETHYLENE-EXTRACTED SOYBEAN OIL MEAL¹

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Although it is common knowledge that heat is used in all the commercial methods of extracting oil from the soybean, little attention has been given to the effect that the amount of heating used has upon the nutritive value of the protein in the residue known as soybean oil meal. With the ever increasing demand for the production of soybean oil, there arises the problem of using the soybean oil meal to its best advantage. Since the meal is destined to be used extensively in rations for poultry and livestock and in the dietary of man, information on the effect heat treatment has on the nutritive value of the proteins in soybean oil meal is important.

In the solvent extraction of oil from soybeans using trichloroethylene, the only significant heating of the meal occurs during the desolventizing and toasting portions of the process. In both of these operations, the commercial equipment and methods used are standardized. Previous investigations relating feed value of the meal to processing conditions, however, show little agreement between the values recommended for the variables of heating time, temperature and moisture content of the meal.

A study of the direct drying characteristics of trichloroethylene-wet soybean flakes, carried out in a cabinet drier, showed that the desolventizing operation

followed a typical drying pattern; and that during the falling rate period, it was the solvent flow within the flakes that determined the drying rate. A drying pattern typical of indirect drying equipment was observed during studies on the Iowa Engineering Experiment Station pilot plant (3) and the Crown Iron Works commercial plant located at Blooming Prairie, Minnesota (4).

In the course of these investigations it was found necessary to determine residual amounts of trichloroethylene in soybean oil meal. To do this, a special colorimetric method was developed which appeared capable of more general application, and was based upon the Fujiwara pyridine-sodium hydroxide color test (2). The reaction was found to obey Beer's law at lower concentrations and to be accurate at concentrations as low as 10 p.p.m.

A recent discovery by Evans and St. John (1) that the glutelin protein fraction in soybean oil meal was proportional to its nutritional value when fed to poultry provided a basis for analytically relating processing conditions to feed value. When soybean oil meal was subjected to dry and moist heat in a specially built laboratory heating apparatus, the glutelin fraction approached a maximum value beyond which additional heat treatment resulted in a decrease, completing a pattern with heating similar to that normally followed by the nutritional value of soybean oil meal. Figure 1 shows the results of these tests which were carried out using a uniform jacket steam pressure but different direct steam pressures. A maximum

1 a. Chairman of Committee, L. K. Arnold, Dept. of Chemical Engineering.

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glutelin content of approximately 53 per cent of the total protein present was obtained in all cases. The amount of protein appearing in the glutelin fraction depended upon the analytical method used. The time required to reach the maximum under similar conditions of temperature and moisture content was found to vary with the manner in which the heating was carried out and the type of equipment used.

Two enzyme systems, urease and lipoxi-

dase activity was destroyed during desolventizing, whereas the urease system required additional heating in the toaster to reduce its activity to a level safe for feeding.

Trichloroethylene itself reduced the lipoxidase activity by 28 per cent in one hour, beyond which the activity continued to decrease. The urease activity was essentially unchanged even upon prolonged contact. The solvent also affected the protein solubility, increasing the water solu-

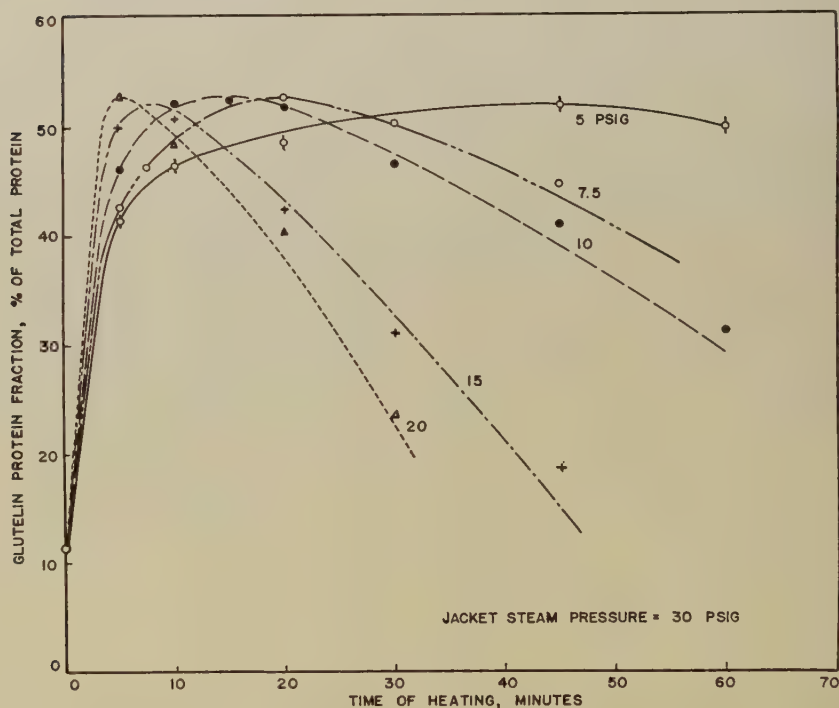


FIG. 1. Effect of moist heat on the glutelin protein fraction in trichloroethylene-extracted soybean oil meal.

dase, are also significant in determining the nutritional value of soybean oil meal. Urease serves as a measure of the antitryptic activity in the meal and lipoxidase is undesirable because of its vitamin A suppressing activity. Both enzyme systems were slowly destroyed by dry heat and rapidly destroyed by moist heat, lipoxidase being the more heat sensitive of the two. In the commercial plant, the lipoxi-

ble portion by 11 per cent and decreasing the glutelin fraction by 2.5 per cent upon two hours contact. Beyond this point, the two fractions increased and decreased respectively.

Additional work is required to confirm the relationship between the glutelin protein fraction and the nutritional value of the meal when it is used in both poultry and livestock feeds.

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COMPLEXES OF NICKEL WITH VIC-DIOXIMES IN THE PRESENCE OF AN OXIDIZING AGENT IN ALKALINE MEDIA¹

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The oxidized complexes of nickel ion with the *vic*-dioximes have been known for about twenty-five years. The red colors of these complexes are the bases of the principal methods used for the spectrophotometric determination of nickel. The orange-red complex, Complex A, is usually formed in ammoniacal solution containing bromine. The red-brown complex, Complex B, can be formed in sodium hydroxide solution containing peroxydisulfate ion; however, air oxidation will produce the complex at a much slower rate. Complex B is a much more stable complex than Complex A.

The chemical literature contains a considerable amount of conflicting evidence as to the actual structures of these complexes. The present work was undertaken to study the nature of these oxidized complexes with the view of improving the analytical procedures which permit the determination of nickel.

The acidic dissociation constants of 2,3-butanedionedioxime, 1,2-cyclohexanedionedioxime and 1,2-cycloheptanedionedioxime were estimated from spectrophotometric data. It was found that removal of the oxime hydrogen atoms occurs at nearly the same pH for each of the three *vic*-dioximes. The value of pK_1 is about 10.6

and of pK_2 about 12.2. These pK values indicate that Complex A is formed by the reaction of nickel ion with the singly charged, *vic*-dioxime anion and Complex B is formed by the reaction of nickel ion with the doubly charged, *vic*-dioxime anion.

The experimental study of Complex B led to a number of conclusions. This complex is a diamagnetic complex of nickel ion containing three *vic*-dioxime molecules. The complex has one or more negative charges. When the complex is decomposed by slow neutralization of its aqueous solution, it gains two electrons. It was concluded that Complex B exists

in aqueous solution as the ion, NiD_3^{2-} , where D designates the doubly charged, *vic*-dioxime anion. Such a formulation indicates an octahedral structure with the bonds being between the nickel(IV) ion and the oxime nitrogen atoms. The greater acidity of Complex B over 1,2-bis(*vic*-dioximo-*N, N'*) nickel (II) is explained because strong hydrogen bonding between the oxime groups is unlikely in an octahedral complex. The formation constant of Complex B prepared with 2,3-butanedionedioxime was found to be about 10^9 . Such a strong complex would be predicted on the basis of the proposed structure.

Complex A is quite unstable. Its color forms rapidly and remains stable for about one hour. After this time, a slow conversion to Complex B begins when Complex A is prepared with 2,3-butanedionedioxime and 1,2-cycloheptanedionedioxime. The conversion of Complex A, prepared

1 a. Chairman of Committee, Chas. V. Banks, Dept. of Chemistry.
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with 1,2-cyclohexanedionedioxime, into Complex B has not been observed. The ratio of *vic*-dioxime to nickel ion was found to be 3:1. Since the spectrum of Complex A is intermediate between that for Complex B and that for 1,2-*vis*-(2,3-butanedionedioximo-*N, N'*) nickel (II), it is hypothesized that Complex A exists in aqueous solution as the ion, $\text{Ni}(\text{DH})_3$. This nickel(III) complex would be expected to be paramagnetic and quite un-

stable since octahedral bonding is impossible without promotion of the unpaired electron to a higher orbital, 5s or 4d.

The results of this work do not indicate ways to improve the methods for the determination of nickel using these complexes. It is suggested that a solubilized nickel(II) compound formed with a sulfonated *vic*-dioxime might prove to be a suitable reagent for the spectrophotometric determination of nickel.

EFFECT OF VITAMIN B_{12} ON GROWTH, FOOD UTILIZATION AND NITROGEN RETENTION IN RATS¹

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This dissertation covers a study of four phases of the nutrition of vitamin B_{12} for growing rats. These are:

1. The effect of vitamin B_{12} on the growth of the rat and the use of the growth response of the rat in assaying for vitamin B_{12} .

2. The effect of vitamin B_{12} on the efficiency of food utilization at different levels of dietary protein.

3. The effect of vitamin B_{12} on the content of non-protein nitrogen in the blood of rats fed different levels of dietary protein.

4. The effect of vitamin B_{12} on the nitrogen retention of the rat.

The presence of vitamin B_{12} in the diet is essential for supporting the growth of rats. The quantity of vitamin B_{12} required for optimum growth of weanling rats was determined by the use of two macrobiological assay procedures; namely, those proposed by Register *et al.* and by Frost *et al.* According to the Register method the B_{12} requirement of the rat for optimal growth is approximately 0.2 microgram daily. By the Frost method it was calculated to be about 0.05 microgram. These values are not in good agreement. The results point to the importance of specifying

the method used in determining the amount of vitamin B_{12} in a material or for optimum rat growth.

The Frost and Register methods were used in comparing the amount of vitamin B_{12} in the kidneys of representative groups of several species of farm livestock. Using the Frost method, the amount of vitamin B_{12} in the kidneys of the beef cattle, hogs, sheep and lambs was found to be 0.04, 0.1, 0.07, and > 0.1 microgram; by the Register method, 0.06, 0.09, 0.11, and 0.14 microgram, respectively, per gram of fresh tissue. Although both methods did not give identical values for the B_{12} content of each kind of kidney, the differences were not great. Both methods revealed that beef kidney has the least B_{12} activity, whereas lamb kidney has the greatest.

The greater growth induced by vitamin B_{12} injection very probably is due to the improved utilization of food by the animal. Since nitrogenous nutrients such as proteins are required for growth, it was decided to determine whether there possibly was any physiological relationship between injection of B_{12} and the amount of protein in the ration of growing rats. Rats injected with none, 0.025, 0.05, and 0.1 microgram of B_{12} daily were caged individually and fed rations containing 8, 12, 18, and 36 per cent of casein. The average growth response of those lots of rats which received vitamin B_{12} was significantly greater than that of those which did not receive B_{12} . Those rats which did not receive vitamin B_{12} required significantly more ration to produce 100 grams of gain in live weight. Furthermore, those rats fed rations

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containing casein supplemented with injections of B_{12} grew as well and utilized their ration as well or better than rats fed similar rations containing much larger percentages of casein unsupplemented with B_{12} . Growth and feed efficiency were better in the lots of rats receiving 18 per cent of casein than in lots receiving 8, 12, and 36 per cent. It appears that a combination of about 18 per cent of casein and between 0.025 to 0.1 microgram of vitamin B_{12} would produce the maximum growth and feed efficiency in rats.

Since injection of vitamin B_{12} in rats stimulates their growth and efficiency of feed utilization, it would appear to play some specific role in affecting the capacity of the animal to utilize protein. The non-protein nitrogen in the blood of rats fed 8, 12, 18, and 36 per cent of casein with or without vitamin B_{12} injections was determined. There was no significant difference in the amount of non-protein nitrogen in the blood of B_{12} -deficient or B_{12} -treated rats fed rations containing the lower levels of casein. However, in the case of the ration containing 36 per cent of casein there was significant difference between the amount of non-protein nitrogen in the blood of B_{12} -deficient and B_{12} -treated rats. It appears that the injection of vitamin B_{12} facilitated the renal elimination of non-protein nitrogen by rats fed large amounts of protein, in this case casein.

The fact that vitamin B_{12} will under certain circumstances increase the growth of rats and improve the efficiency with which they utilize food, indicates that these animals may have the ability to retain a larger amount of nitrogen for metabolic purposes than retained by B_{12} -deficient rats. The effect of vitamin B_{12} injection on the retention of nitrogen by rats fed rations supplemented with different kinds and amounts of proteins and amino acids was determined.

It was found that vitamin B_{12} did not increase the amount of nitrogen retained by rats when they were fed a ration containing 18 per cent casein either with or without supplemental additions of protamone if their bodies were not first depleted of B_{12} reserves. Vitamin B_{12} was effective in increasing nitrogen retention in rats when they were fed rations containing moderate or large percentages of soybean oil meal provided the experimental period was preceded by a B_{12} -depletion period. The nitrogen retention of rats fed a "protamonized" 18 per cent soybean oil meal ration was increased when methionine was added to the ration. Rats fed the same ration and simultaneously injected with B_{12} failed to retain additional nitrogen. However, when the methionine was replaced with homocystine a considerable increase in nitrogen retention was obtained. Thus, vitamin B_{12} enables homocystine to accomplish a role similar to methionine in the protamonized 18 per cent soybean oil meal ration.

Injection of vitamin B_{12} also brought about an increase of nitrogen retention in rats fed a soybean oil meal ration supplemented with either tyrosine or phenylalanine. As there was no accumulation of tyrosine metabolites in the urine of tyrosine supplemented rats it would appear that vitamin B_{12} is not involved in tyrosine catabolism as it apparently is in the scorbutic guinea pig.

The use of the antibiotic aureomycin in the soybean oil meal ration did not appear to replace vitamin B_{12} in increasing the nitrogen retention in rats.

The results of these nitrogen balance studies indicate that under certain conditions the nitrogen retention of rats can be increased by vitamin B_{12} administration. Also, it appears that when the appropriate precursor is present in the ration, B_{12} may act in some way in the formation of methionine.

VOLUTELLA SPECIES ON ALFALFA¹

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Department of Botany and Plant Pathology

Observations of greenhouse grown forage legume accessions of the Plant Introduction Station revealed three species of *Volutella* infesting the 1949 plantings. *Volutella gilva* (Pers. ex Fr.) Sacc., previously reported in Europe and New York on alfalfa and clovers, was characterized by large, rosy, pulvinate sporodochia with conspicuous, white, flexuous setae. *V. ciliata* (Alb. et Schwein.) Fr., reported from Europe on alfalfa and clovers, produced dingy-gray colored, substipitate sporodochia with rigid, white setae. Both of these species have been reported on unrelated plants and are generally conceded to be saprophytic. The third species encountered produced small, pink, superficial sporodochia beset with a few short, dark-colored, rigid setae and exhibited parasitic capabilities. No previous description of this fungus has been reported.

Field observations during the summers of 1950-1951 showed a low incidence of the three fungi. The dark setose species was confined to Plant Introduction accessions. The fungus was able to maintain itself through the winter in the field; however, no increase of incidence or spread of this fungus was detected during the two summers. The restriction of the dark setose fungus to Plant Introduction stocks was further shown by observations of plants grown at the Nebraska Agricultural Experiment Station from seed of the same lots as were planted in Ames. All samples there of the 1949 plantings yielded the fungus; no sign of the fungus was found on the 1950 plantings.

Greenhouse inoculation experiments showed that *V. gilva* and *V. ciliata* were not parasites of alfalfa or red clover. Successful infections by the dark setose species were established on alfalfa and red clover seedlings from seed borne inoculum and spray inoculations. Infected seedlings were characterized by a rapid water-soaking,

followed by necrosis and shrivelling. Infections on older plants were localized, the mycelium invading the cortex intracellularly, with petiole necrosis and elongate, sunken stem lesions resulting. Infections were also noted on *Medicago falcata*, *Lotus corniculata*, and *Trifolium hybridum*. Nine alfalfa varieties and eight red clover varieties showed only slight susceptibility to the fungus.

Natural contamination by the dark setose fungus of Plant Introduction seed or seed from inoculated plants was not found. Red clover seed, artificially infested with conidia, maintained viable conidia for more than twelve months.

The sporodochium of *V. gilva* originated by the emergence of mycelium to the host surface where it branched to form a loose network. Simple, single-celled conidiophores, intermixed with the setae, developed a parallel layer of strands over this network, producing a large number of conidia in a mucus mass. The conidia were cylindrical, 7-12(9.5) by 2-3 microns. *V. ciliata* produced a pseudoparenchymatous stroma within the tissues which emerged to form the stipe of the sporodochium. Setae and 2-3 septate conidiophores developed from the stipe. The mucus imbedded conidia were elliptical, 4-9(6) by 2 microns.

The sporodochium of the dark setose species developed by the emergence of a slight tuft of mycelium from the surface of the host tissues to form a cushion-shaped base for the structure. A dense, parallel layer of single-celled, simple conidiophores, 18-40 by 2-3 microns, radiated outward from this base, presenting a fan-shaped appearance in median section. The conidia, produced in a mucus mass, were hyaline, single-celled, navicular, 6-9(7.5) by 2.5-3.5 microns. The few dark setae originated in the mycelial base of the sporodochium and were 2-4 septate, 60-90 by 3-4 microns, primarily marginal. On potato dextrose agar this fungus produced a pink to brownish appressed, convolute growth with occasionally setose sporodochia arising from the mycelial mat. Aerial mycelium rarely occurred.

1 a. Chairman of Committee, Joseph C. Gilman, Dept. of Botany and Plant Pathology.

b. Doctoral Thesis No. 1276. Submitted June 3, 1952.

2 a. B.S., Arizona State College, Tempe, Ariz., 1948.
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Among isolates obtained from field inoculations of the dark setose species was a fungus which produced similar conidia on an elevated fruiting structure, but differed from the original isolates by being much more densely setose. The setose characteristic remained constant through single-spore transfers, different media, and various environmental changes. Nutritional studies revealed that the two forms differed somewhat in growth response to different sugar and nitrogen sources. The best sugar source for both was dextrose, with differential preferences for l-arabinose and d-lactose. Both strains best utilized valine of the amino acids; cysteine was inhibitory to both. Both strains required exogenous biotin for vigorous growth, the densely setose strain being sensitive to 0.1 microgram per liter of biotin, the sparsely setose strain being sensitive to 1.0 microgram. No benefit was evident from supplements of other vitamins. Other similarities were similar growth response to temperature and pH changes, development of the sporodochium, and setae dimensions. Growth on potato

dextrose agar was similar for both strains, but the densely setose variant could usually be differentiated by the appearance of marginal setae. On Czapek's agar fortified with biotin the sparsely setose strain differed in being smooth and somewhat zonate as contrasted with a roughened growth of the densely setose strain.

The evidence obtained in this work indicates that a previously unreported parasite of alfalfa and red clover has been found. The fact that the fungus was discovered on and confined to accessions of the Plant Introduction Station both in Ames and Lincoln, Nebraska, the ability of seed inoculum to initiate infection, and the lack of a previous description of the fungus on a pathologically well known crop such as alfalfa indicates the probable introduction of the fungus on seed of the Plant Introduction Station. The lack of an observable increase in the incidence of the fungus in the field and the lack of high susceptibility of native varieties to the fungus justify concluding that the fungus will not become economically significant.

SOLUTIONS BY DUAL INTEGRAL EQUATIONS OF MIXED BOUNDARY VALUE PROBLEMS IN ELASTICITY¹

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The problem of the determination of the stress and strain in a semi-infinite elastic medium with a plane boundary which is loaded in some way is well known, and its history dates back to Boussinesq's famous memoir of 1885. In the work of Boussinesq and of other writers on the topic, usually the load is prescribed over the plane boundary. The solution for a point load provides a Green's function from which the solution for other loadings can be obtained.

If, however, the situation is varied so that the normal displacement is prescribed

over a portion of the boundary and the load prescribed over the remaining part, one has a mixed boundary value problem which is rather more complicated. This dissertation is primarily concerned with some problems of this nature. Sometimes these are called punch problems, since a rigid punch, driven into the surface, prescribes the normal displacement over the region of contact.

In 1945, J. W. Harding and I. N. Sneddon introduced a new method of handling such problems when there is symmetry about an axis normal to the boundary. By using Hankel transforms, they showed how to reduce the main part of such a problem to the task of solving a pair of dual integral equations. Using this approach, Sneddon subsequently gave a detailed analysis of the stress and strain in the medium when the punch is a right

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M.S., *ibid.*, 1943.

circular cylinder or cone and the medium is isotropic. His results for the cone agreed with those previously obtained by A. E. H. Love and were more complete, since Love had not determined the stress at an

where $f(t)$ is the unknown function to be found. An explicit solution for $f(t)$ has been given by I. W. Busbridge whose formula is established under the restrictions

$$s > -2, -p - 1 < s - \frac{1}{2} < p + 1. \quad (2)$$

interior point of the medium. In Chapter III of this thesis, an analysis similar to that of Sneddon is undertaken when the

In the indentation problems described above, the dual equations (1) have to be solved for the two cases

$$(i) \quad s = -1, p = 0, g(u) = \text{polynomial in } u,$$

$$(ii) \quad s = -1, p = -\frac{1}{2}, \sqrt{u} g(u) = \text{polynomial in } u.$$

indenting surface is expressible in cylindrical coordinates in the form $z = \text{polynomial in } r$, thus including the cone and cylinder as special cases. A noteworthy feature of the results is the fact that the stress and displacement components at any point are obtainable explicitly in terms of elementary functions. Also, it is shown how to calculate the depth of penetration and the radius of the circle of contact in terms of the total load and the other constants of the problem. Spherical indentation is given special consideration, including, in particular, the determination of the maximum shearing stress in the medium.

In Chapter IV, the analogous two-dimensional plane-strain problem is studied for an orthotropic medium. Here, Fourier transforms are used to obtain a pair of dual integral equations whose solution leads to the determination of the stress and displacement components at any point of the medium. Again the results are obtained in simple form suitable for computational purposes. By letting one of the elastic parameters tend to unity one deduces the results for the isotropic case and these are found to be in general agreement with formulas given by Sneddon. However, Sneddon's presentation (which is confined to the isotropic case) is rather unsatisfactory, even though he obtains essentially correct answers, so that the procedure used in this thesis is not precisely similar to his, the main difference being in the treatment of the dual equations as indicated below.

The dual integral equations which arise are of the type

$$\int_0^{\infty} t^s f(t) J_p(ut) dt = g(u), \quad 0 < u < 1, \quad (1)$$

$$\int_0^{\infty} f(t) J_p(ut) dt = 0, \quad u > 1,$$

Both of these cases violate condition (2). In case (i) it is found that the Busbridge formula still provides a solution; but, in case (ii) it is shown that the formula definitely fails unless there is a certain linear relation among the coefficients of the polynomial. Sneddon, in the plane-strain problem discussed above, uses the Busbridge formula without comment and later has to adjust a certain parameter to obtain the final answers. The procedure used in this thesis is rather more natural and convincing.

In the derivation of the solutions of the punch problems described above, certain assumptions are made, from time to time, on the behavior of the potential function which are not immediately justifiable on mathematical grounds although they are plausible for physical reasons. It is therefore desirable to verify that the final solutions do, in fact, satisfy the basic equations and the boundary conditions. This verification is carried out in detail for the plane-strain problem of this thesis and it can clearly be done for the other problem also.

It is assumed throughout that the strains are small and that elastic statical conditions prevail. Nevertheless, as has been remarked by Sneddon, results obtained in this way can give useful information in certain dynamical situations (e.g., in the theory of armor penetration) if the velocity of the indenting agent is small compared with the velocity of waves in the elastic medium. Applications to some problems of soil mechanics are also feasible.

HIGH SPECIFIC RADIOACTIVITIES OF COBALT, PLATINUM AND IRIIDIUM FROM PHOTONUCLEAR REACTIONS¹

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The attainment of high specific activities is an important requirement for the detection and utilization of radio-activities produced by photonuclear reactions. If an element different from the target element is produced, suitable chemical procedures for the separation of the radioactive atoms from the target atoms can usually be found. However, finding rapid and efficient methods for separating isotopes of the target element formed by the (γ, n) reaction presents a more difficult problem. To facilitate the study of the properties of cobalt and platinum activities produced in the synchrotron by (γ, n) reactions, an attempt was made to find complexes of these elements which would undergo Szilard-Chalmers type reactions. A portion of the study was also devoted to the investigation of the activities formed by photonuclear reactions in platinum when $\text{PtCl}_4 \cdot x\text{H}_2\text{O}$ is irradiated in the x-ray beam of the synchrotron.

Samples of $\text{K}_3[\text{Co}(\text{C}_2\text{O}_4)_3] \cdot 3\text{H}_2\text{O}$ were irradiated in the x-ray beam of the 68 Mev synchrotron. The Szilard-Chalmers process appeared to be nearly 100 per cent effective in ejecting the radioactive cobalt atoms from the complex. The 9.2h $\text{Co}^{58\text{m}}$ and the 72d Co^{58} formed during the irradiation were separated from the complex in high specific activities by adsorption on IRC-50 cation exchange resin. A solution of the complex was prepared from active cobalt separated in this way. A method utilizing the chemical decomposition of the

complex which occurred as a result of the decay of $\text{Co}^{58\text{m}}$ to Co^{58} by the emission of conversion electrons, was used to calculate the ratio of the rates of formation of the two isomers. In these experiments the ratio of the rate of formation of Co^{58} to the rate of formation of $\text{Co}^{58\text{m}}$ was found to be 0.61 ± 0.04 . The total saturation yield of $\text{Co}^{58\text{m}}$ and Co^{58} relative to C^{11} was determined to be 8.6.

It was necessary to use a windowless Geiger-Mueller type gas flow counter to detect the low energy radiation of $\text{Co}^{58\text{m}}$. Some preliminary experiments to determine the back-scattering corrections for this counter were therefore performed. The backscattering of four different beta-emitters ranging in energy from 0.067 to 1.7 Mev was investigated. The backscattering was found to be a function of the atomic number of the backscatterer. With platinum backing, the backscattering appeared to have reached a saturation value and was nearly the same for all of these beta energies. The over-all efficiency of the counter was about 78 per cent for samples mounted on platinum.

In synchrotron irradiations of $\text{PtCl}_4 \cdot x\text{H}_2\text{O}$, 88m, 18h and 4d platinum activities and 7m, 140m, 19h, and 70d iridium activities were detected. Their yields relative to that of the 18h Pt^{197} and the 33m Cl^{34} were determined. The mass assignments and characteristics of the two new iridium activities were studied. The 140m activity was tentatively assigned to Ir^{195} and the 7m activity to Ir^{193} or Ir^{197} . Szilard-Chalmers process separation methods were also investigated for the following complex compounds of platinum: K_2PtCl_6 , $[\text{Pt}(\text{NH}_3)_2\text{Cl}_4]$, $[\text{Pt}(\text{NH}_3)_4]\text{Cl}_2$, and $[\text{Pt}(\text{NH}_3)_4]\text{C}_2\text{O}_4$.

1 a. Chairman of Committee, Don S. Martin, Dept. of Chemistry.

b. Doctoral Thesis No. 1237. Submitted December 12, 1951.

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ADJUSTING FARM RENTS TO CHANGES IN PRICES, COSTS AND PRODUCTION¹

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Incomes of nearly a quarter of a million Iowans are determined in part by terms of rental agreements which remain rigid in a dynamic environment of changing prices, costs and production. Changes in economic factors affect the division of net returns differently under each lease type, which results in a source of confusion and conflict to landlords and tenants and the use of corrective measures that have proven costly to both the individuals involved and to society. The objectives of the study concern the determination of the extent of the variation in the division of net returns under each lease type over time; the effect of this variation on landlord-tenant relations; the methods used by landlords and tenants to make corrections for changes in the division of net returns; and the analyses of possible means of introducing flexibilities into the rental arrangements.

To determine the extent of variation of the incomes of landlords and tenants under conditions of changing prices, costs and production, records of cooperators with the Iowa Farm Business Associations were investigated for the period 1920-1950. Additional information on the measures used for rent adjustment in the 1939-1950 period, and the success of the measures, was obtained from interviews with 65 tenants and 25 of their landlords.

Analysis of records indicated that the landlords renting for cash have received an increasingly smaller share of the net returns since 1933, having received 26 per cent of the net return in 1933 and 13 per cent in 1950. The rate of decrease has been an estimated .67 per cent per year. The stock-share landlord, on the other hand, has received a larger share of the net returns during the period, receiving an esti-

mated 41 per cent in 1933 and 52 per cent in 1950. The trend of the landlord's share has increased .47 per cent per year. Crop-share landlords have fared similarly with the stock-share landlords, the landlord's share increasing an estimated .67 per cent per year in the 1933-1950 period.

To determine the effect of the changes on the division of net returns on landlord-tenant relations and to determine the methods used for purposes of adjustment, landlords and tenants making four types of changes were interviewed. The changes investigated were (1) changes in lease provisions, (2) changes in lease types, (3) changes in farms and (4) changes to ownership.

The interviews indicated that landlords and tenants made relatively few changes in lease provisions to adjust for changes in prices, costs and production. Cash leases investigated in the 1939-1950 period totaled 209 years; crop-share leases totaled 199 years; and stock-share leases totaled 200 years. Of the 49 changes in cash lease provisions found, 48 were changes in the cash rent. As the period studied was one of rising prices, and it has been determined that cash rent lags prices by one to two years, the changes were not as satisfactory to the landlords as to the tenants.

Crop-share leases investigated contained only 11 changes in lease provisions, eight of which were changes in the amount of cash rent. Only two cases were found in which share proportions were changed to adjust for changes in prices, costs and production. Adjustments in cash rents provided a satisfactory means of altering the division of net returns for the tenant as the rent on hay and pasture land was usually less than rent on share rented land.

The 14 changes in stock-share lease provisions were made to compensate the tenant for his increased operating costs, and involved transferring enterprises between parties or changing the ratio of contribution. Where the enterprise transferred, or the amount of the landlords' increased contribution substantially altered the division of net returns, the change was suc-

1 a. Chairman of Committee, John F. Timmons, Dept. of Economics and Sociology.
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cessful in preserving the rental relationship.

Relatively few landlords and tenants change lease types without changing rental partners. Lease type changes investigated indicated that changes from the cash lease were made at the landlords' suggestion and changes from the stock-share leases were made at the tenants' suggestion. Changes to the cash lease were initiated by the tenant; changes to the stock-share lease were initiated by the landlord. As few changes in lease type without changing farms were encountered, it is believed that this technique is not widely used.

Changes in farms are frequently accompanied by changes in lease types; 18 tenants were interviewed who had changed farms and 14 of these tenants made the change because of an unsatisfactory rental arrangement. Of these 14 tenants, 13 changed their lease type at the time of the move. As the changes occurred in a period of rising prices, when the cash lease was most favorable to the tenant and the stock-share lease was the least favorable, eight were changes from the stock-share arrangements and only two were changes from the cash plan.

A total of 20 tenants who had become owners were interviewed. Of these tenants, 11 purchased farms either as a result of inability to secure a satisfactory rental arrangement or because ownership costs failed to advance as rapidly as rent.

Methods that have been developed and used by landlords and tenants to adjust rent without changing lease types or farms involve postponement of negotiation of the rent until the end of the production period or provision for the rent to vary with changes in prices, costs and production. Both techniques were found in the study and both have a long history of maintaining a workable situation between landlords and tenants. Plans basing the rent upon the prices of farm products may provide protection to the tenant against abrupt price changes and give the landlord a rent based upon value productivity when prices are rising. Changes in production, how-

ever, may offset price changes and defeat the purpose of the adjustment based upon price alone. Plans based upon both prices and production provide full protection to both landlord and tenant as the rent is correlated with the value productivity of the farm. Further study and refinement of these plans are necessary to increase their area of application.

Some recent developments in landlord-tenant law in other countries, notably France, England and the Netherlands, may have some application in the United States. These laws provide for the use of long term leases with the right of landlords and tenants to appeal to the courts for rental adjustments. In the setting of rental rates based upon current prices, costs and production, the courts have the advice of tribunals made up of representatives of tenants, landlords and government. Thus, rental rates are adjusted without recourse to the individually and socially costly techniques associated with changes in farms.

In summary, the landlords' share of the net returns has been increasing since 1933 under the crop-share and stock-share arrangements, and decreasing under the cash plan. Landlords and tenants, in seeking to make adjustments for these changes, have encountered difficulty in changing lease provisions and changing lease types without changing farms or tenants. A large proportion of tenants changing farms make the change to secure another lease type. Also, about half of the tenants interviewed who secured ownership made the change because of an unfavorable rental situation. Many of these changes possibly could be avoided if methods of adjusting rent presented in the study were further refined and made available to landlords and tenants seeking help on rental problems. In addition, the recent developments in foreign countries could profitably be studied to determine the possible extent of their use in improving landlord-tenant relations and in reducing tenant mobility in the United States.

OBJECTIVE CARCASS GRADE SPECIFICATIONS FOR SLAUGHTER STEERS¹

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Researchers in the past have assumed that consumers directed production efficiently through the pricing mechanism. Many cases exist where this assumption needs to be re-evaluated. An illustration of this is found in livestock marketing. The pricing mechanism reflects price somewhat inaccurately to the producer. The producer fails to receive the proper incentive to change production to the quantity and quality of the product that consumers prefer.

The pricing mechanism fails to allocate resources efficiently in production because price differentials for different grades of meat at the consumer level are not fully-accurately transmitted back to the producer.

Price differentials for different grades of meat cannot be maintained through the complex marketing system unless uniform grade standards are in general use.

Although official carcass grade standards for beef cattle have been specified by the United States Department of Agriculture, they have not been accepted by all concerned. Many reasons have been given for the failure of these grades to be accepted and used universally.

One major reason for their failure to be adopted is that they are subjective and there is no clear-cut set of specifications which divide the carcasses into homogeneous groups.

The purpose of this study is to investigate the possibility that the subjective terms which are now used could be described accurately by objective measurements of the carcasses.

The relationships between various measurements and grades were studied. Eye-

fat thickness³ was found to be most closely related to grade, with length and carcass weight following in that order.

A regression equation using weight, length, and eyefat thickness was found to be highly correlated with grade ($R = .89$). These variables were used to develop tentative objective carcass grade specifications for slaughter steers.

By the use of the proposed grade standard, about 90 per cent of the carcasses in the sample were placed in the same United States official carcass grade for beef as that graded by the government graders.

More duplication of the study is necessary before these relationships can be verified. Even if these relationships are valid for all cattle, factors other than weight, length, and eyefat thickness (for instance, color, marbling, area of eye muscle, etc.) must be considered before the final grading of the carcass can be made.

This study gives some indication of the possibility of developing objective carcass grade specifications for slaughter cattle. Additional research in this area might prove to be very profitable.

The adoption of objective carcass grade specifications would have many implications. The most important effect would be on commercial transactions. The terms used would convey the same meaning to the buyer and seller, thus, the trading would be done on a descriptive basis.

This would make marketing of livestock more efficient as it would eliminate part of the resources employed in the present marketing systems. This decrease in the cost of marketing of livestock should benefit the producer and the consumer as they would share this gain in efficiency.

Some other obvious improvements in

1 a. Chairman of Committee, Geoffrey Shepherd, Dept. of Economics and Sociology.
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3 Eyefat thickness is the width of fat between the exterior of the carcass and the eye muscle. This measurement was taken on the face of the thirteenth rib of the carcass, three-fourths of the length of the eye muscle from the backbone.

the marketing of livestock would include: (1) more intelligible market news information; (2) a more accurate determination of values; and (3) a change in production toward those types and breeds of livestock preferred by the consumer.

The adoption of these standards would also have many far-reaching effects. An illustration of one of these might be the

development of a new score card for livestock judges to use in placing the animals in show rings. If objective measures could be formulated in an equation which would accurately determine grades, it would be a relatively simple matter to find the relative importance of each variable. The points on the score card would be based on these relative values.

GENETIC COVARIATION AMONG CHARACTERISTICS OF SWINE¹

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The two primary purposes of this study were: (1) to investigate the heritability of litter size and of growth in swine and (2) to investigate the genetic relationship between litter size and growth. The study also yielded information on phenotypic variances and correlations. Litter size was measured by number of pigs at three different ages: birth, 56 days, and 154 days. Growth was measured by weight at 56 days and 154 days.

The data came from twelve inbred lines of Poland China swine and one inbred line of Danish Landrace and encompassed a total of 1,980 litters. The analyses of the variation were within groups in which all individuals were contemporary with respect to line, year, season, and age of dam.

Heritability was estimated as twice the regression of daughter or litter on dam. The numerical values thus obtained were as follows:

Number born	$-.11 \pm .07$
Number at 56 days	$-.09 \pm .08$
Number at 154 days	$-.15 \pm .08$
Weight at 56 days	$.03 \pm .08$
Weight at 154 days	$.07 \pm .10$

Correlations between one trait for the offspring and another for the dam were

also computed. Litter size and weight were indicated to be positively related genetically, although the relationship was too small to be statistically significant on this volume of data. Additive genetic effects for growth before weaning appeared to be independent of those for growth after weaning.

The role that overdominance and selection might play in causing the parent-offspring regression to be negative was investigated theoretically. Cases are presented in which the parent-offspring regression would be negative. The most likely case is that in which selection keeps gene frequency slightly less than that which would make yield of the character maximum. This requires that overdominance be more extreme on the selection scale than on the yield scale. Even in this case, overdominance on the selection scale can be only slightly greater than overdominance on the yield scale.

Sampling errors or a rather delicate balance of overdominance and selection seem to be the only plausible explanations for the negativeness of the observed estimates of heritability for litter size. Tentatively, heritability of litter size (in the additive sense) is concluded to be zero or very nearly zero. Yet the inbreeding depression and the differentiation of lines indicate that hereditary differences of some kind were present in considerable amounts. Even for weight, the estimates of additive heritability are too small to be significantly different from zero on this volume of data.

- 1 a. Chairmen of Committee, Jay L. Lush, Dept. of Animal Husbandry, and John W. Gowen, Dept. of Genetics.
b. Doctoral Thesis No. 1275. Submitted June 3, 1952.
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THE MECHANISM OF THE BENZIDINE REARRANGEMENT¹

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It has previously been established³ that the benzidine rearrangement is of second order in hydrogen ion. This work was designed to obtain more detailed information about the mechanism. Specifically, the problem was to determine whether or not the second proton transfer to hydrazobenzene is the rate-determining step. To this end the rearrangement was investigated for general acid catalysis. Two tests for such catalysis were applied.

For the first test the catalysts consisted of formic, chloroacetic or phosphoric acid in ethanol-water, neutralized to various extents with sodium ethoxide, and brought to constant ionic strength with lithium perchlorate. The results show that at any one pH meter reading, the rates vary largely from acid to acid.

The second test utilized buffer solutions of formic, glycolic, chloroacetic, salicylic and cyanoacetic acids with their sodium salts. All solutions used were of pH 2.33 ± 0.06 , but the absolute amounts of the acids were varied from run to run. Constant ionic strength was maintained by use of potassium chloride. It was found that the rate of rearrangement is sensitive to the amount of acid added. The rate corresponding to zero concentration of undissociated acid was obtained by using hydrochloric acid — potassium chloride solutions of the same pH and ionic strength.

Solutions which do not differ largely in composition and give the same pH meter readings are believed to have approximately the same hydrogen ion activities.

On this basis, the rate of the benzidine rearrangement is sensitive to the concentration and nature of undissociated acid, under conditions of constant ionic strength and hydrogen ion activity. Thus the rearrangement is subject to general acid catalysis.

These kinetic results suggest that the transition-state is composed of a molecule of hydrazobenzene, two protons and an acid anion. In other words, the second proton transfer is rate-determining. To confirm this a compound, which Pongratz⁴ has described as hydrazobenzene dihydroiodide, was prepared and its properties investigated. No unequivocal proof of its structure was obtained, but it was shown that it is an hydroiodide and that it differs from benzidine dihydroiodide in physical properties. Its chemical properties suggest that it rearranges very rapidly in solution when some water is present.

It is not possible to calculate, even approximately, the expected activation energy for the proton transfer, since the energies of solvation are unknown. However, a rough calculation using bond energies, electron affinities and a Coulomb interaction places the configuration of the transition-state close to that of the di-conjugate acid.

The logarithms of the catalytic constants of the acids do not vary in a linear manner with the pK values of these acids. An analysis of the thermodynamics of the process shows that this is probably due to the difference in charge types between the bases involved in the rearrangement and in the pK measurements. The thermodynamics also demonstrates that it is not possible to determine the rate-determining step by studies of the dependence of the rate of rearrangement on ionic strength.

1 a. Chairman of Committee, George S. Hammond, Dept. of Chemistry.

b. Doctoral Thesis No. 1293. Submitted June 7, 1952.

2 a. B.Sc., University of Cape Town, Cape Town, Union of South Africa, 1946.
B.Sc., University of South Africa, 1947.
M.Sc., *ibid.*, 1948. (Pietermaritzburg, Union of South Africa.)

3 Hammond and Shine, *J. Am. Chem. Soc.*, **72**, 220 (1950).

4 Pongratz, Bohmert-Suss and Schollis, *Ber.*, **77**, 651 (1944).

THERMODYNAMIC AND KINETIC PROPERTIES OF METAL IONS IN AQUEOUS SOLUTION¹

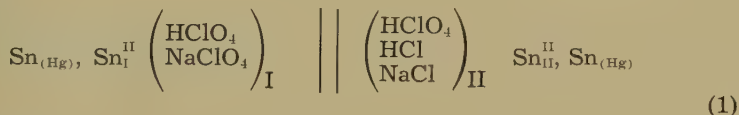
WELBY G. COURTNEY²

Department of Chemistry

While it is evident that a metal ion in aqueous solution interacts electrostatically with water molecules and the anions present in the solution, it is equally apparent that often the metal ion chemically combines with varying numbers of ions or molecules to form complex species. This tendency towards coordination complexing is observed most often with the transition metals and results in a series of complex species MA_n with n being the number of ligand molecules A which are complexed to the metal ion M and is equal to 1, 2, . . . , $N-1$, N , where N is the maximum observed coordination number but not necessarily identical with Werner's coordination number for the metal ion. A portion of the work abstracted in this paper was concerned with devising a simple method for the determination of k'_n , where $k'_n = (MA_n)/(MA_{n-1})(A)$.

Stannous Chloride Equilibrium Constants. The potential of a concentration cell is related by the familiar Nernst equation to the activities of the aqueous metal ion in the two half cells if the electrode activities are the same and if junction potentials are assumed eliminated. Therefore, if both half cells contain solutions at equal ionic strength, the potential of the cell may be related to the variation in activity of the metal ion due to its complexing.

The stannous chloride complexes, $N = 4$, prove to be a system amenable to such an experimental procedure. Consider the system:



then

$$\exp(-E/0.0128) = 1 + k'_1 T_{\text{Cl}^-} + k'_1 k'_2 T_{\text{Cl}^-}^2 + k'_1 k'_2 k'_3 T_{\text{Cl}^-}^3 + k'_1 k'_2 k'_3 k'_4 T_{\text{Cl}^-}^4$$

where E is the potential of the cell, T_{Cl^-} the total or formal chloride concentration

in half cell II, and $k'_n = (\text{SnCl}_n^{2-n})/(\text{SnCl}_{n-1}^{3-n}(\text{Cl}^-))$. Equation (1) is valid since: (1) both amalgam electrodes were of equal activity; (2) constant ionic strength, 2.03, was maintained in both half cells; (3) chloride ion was in excess such that $(\text{Cl}^-) = T_{\text{Cl}^-}$; (4) the ionic mobilities of chloride and perchlorate are not so dissimilar so that a NH_4NO_3 salt bridge may be assumed to eliminate junction potentials; and (5) a high acid concentration, $(\text{H}^+) = 2.00$, was maintained to reduce hydrolysis of the tin(II)³ to negligible proportions. Under these conditions a comparison of the empirical curve of $\exp(-E/0.0128)$ vs T_{Cl^-} to equation (1) allows a determination of k'_{II} .

The following values for the equilibrium constants were obtained at $\mu = 2.03$, $T = 25.0 \pm 0.1^\circ\text{C}$:

$$\begin{aligned} k'_1 &= 11.3 \pm 0.2 \\ k'_2 &= 5.1 \pm 0.2 \\ k'_3 &= 0.24 \pm 0.05 \\ k'_4 &= 1.0 \pm 0.4 \end{aligned} \quad (2)$$

The stannous chloride constants were determined by Prytz⁴ for $\mu = 0$, but the values for k'_n in (2) are believed to be the more accurately determined.

Mechanism of the $\text{Cu(II)}-\text{CN}^-$ Reaction. Studies of the mechanism of electron transfer have demonstrated that complexes often play a pertinent role in the oxidation re-

1 a. Chairman of Committee, Frederick R. Duke, Dept. of Chemistry.
b. Doctoral Thesis No. 1186. Submitted June 26, 1951.
2 a. B.A., Oberlin College, Oberlin, Ohio, 1949.
b. Assistant, Institute for Atomic Research.

action, and a possible generalization may be stated: coordination complexes are in-
3 Gorman, *J. Am. Chem. Soc.*, **61**, 3342 (1939).
4 Prytz, *Z. anorg. Chem.*, **172**, 147 (1925).

olved mechanistically as intermediates in homogeneous ionic oxidation-reduction reactions. This hypothesis appears to be particularly applicable to reactions involving cationic oxidizing agents and anionic reducing agents.

A further point of interest in connection with coordination intermediates is any relationship which might exist between the number of oxidizable anions in the complex and the rate of electron transfer.

The present work examines the $\text{Cu(II)}-\text{CN}^-$ reaction from the points of view outlined above. The numerous cyanide complexes of both copper(I) and (II) indicate that in this reaction any relationship between the intermediate and its rate of reaction could perhaps be recognized more easily than for other reactions.

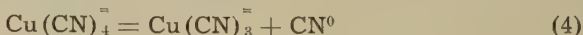
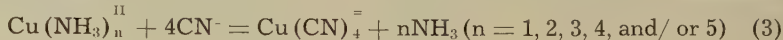
Since it was observed that ammonia slowed the reaction, the disappearance of Cu(II) was kinetically studied in a con-

sidering the series of reactions where various cupric cyanide complexes disproportionate to give the cuprous cyanide complexes with one less cyanide and a cyanide radical, the high free energies of the products, excepting the tricyanide complex, indicate that the free energy of activation may be directly correlated to the free energy content of the product. Thus, in a reaction of the type $\text{A} \rightarrow \text{B} + \text{C}$, the activated complex resembles the products rather than the reactant.

A subsidiary study of the reaction was made to determine the cause of the distinct violet color when cyanide ion is added to ammoniated copper(II). Considering the extinction at zero time, D_0 at $615 \text{ m}\mu$, of a $\text{Cu(II)}-\text{CN}^- \cdot \text{NH}_3$ solution, if D'_0 is the absorption of the cupric-cyanide complex and D''_0 that of the cupric-ammonia complexes, then $K = (\text{Cu(CN)}_x^{2-x})/(\text{Cu}^{II})(\text{CN})^x$ and

$$D_0 = \left(\frac{K}{k} - \frac{K}{k'} \right) (\text{Cu}^{II}) (\text{CN}^-)^x + \frac{T_{\text{Cu}^{II}}^0}{k'} \quad (6)$$

centrated (10.5-12.5M) ammonia solution. The results for $\mu = 1.00$ and $T = 0 \pm 0.1^\circ\text{C}$, indicate the following mechanism, with a negligible amount of copper(II) in the cyanide complex:



$$\frac{-dT_{\text{Cu}^{II}}}{dT} = k(\text{Cu}(\text{CN})_4^{=}) = \frac{kK(T_{\text{Cu}^{II}}^0)(T_{\text{CN}^-}^0 - 4T_{\text{Cu}^{II}}^0 + 4T_{\text{Cu}^{II}}^0)^4}{k'_1 \dots k'_4 a_{\text{NH}_3}^4 + k'_1 \dots k'_5 a_{\text{NH}_3}^5} \quad (5)$$

where T_x is the total concentration of x at time t , with T_x^0 referring to zero time,

$K = \text{Cu}(\text{CN})_4^{=} / (\text{Cu}^{II})(\text{CN}^-)^4$ and $k'_n = (\text{Cu}(\text{NH}_3)_n^{II}) / (\text{Cu}(\text{NH}_3)_{n-1}^{II})(\text{NH}_3)$. The

rapidity of the reaction limited the available range in ammonia concentration so that the intermediate disproportionating complex may contain one or two molecules of ammonia. The author feels that the latter mechanisms are less probable. Con-

sidering the series of reactions where various cupric cyanide complexes disproportionate to give the cuprous cyanide complexes with one less cyanide and a cyanide radical, the high free energies of the products, excepting the tricyanide complex, indicate that the free energy of activation may be directly correlated to the free energy content of the product.

Thus, in a reaction of the type $\text{A} \rightarrow \text{B} + \text{C}$, the activated complex resembles the products rather than the reactant.

A subsidiary study of the reaction was made to determine the cause of the distinct violet color when cyanide ion is added to ammoniated copper(II). Considering the extinction at zero time, D_0 at $615 \text{ m}\mu$, of a $\text{Cu(II)}-\text{CN}^- \cdot \text{NH}_3$ solution, if D'_0 is the absorption of the cupric-cyanide complex and D''_0 that of the cupric-ammonia complexes, then $K = (\text{Cu(CN)}_x^{2-x})/(\text{Cu}^{II})(\text{CN})^x$ and

$D_0 = \left(\frac{K}{k} - \frac{K}{k'} \right) (\text{Cu}^{II}) (\text{CN}^-)^x + \frac{T_{\text{Cu}^{II}}^0}{k'}$

where k is the extinction coefficient of

$\text{Cu}(\text{CN})_x^{2-x}$ and k' that of the cupric-ammonia complexes. Since the ammonia concentration is large in comparison to that of

the copper(II), the concentrations of the ammonia complexes may be expected to remain approximately constant if varying

cyanide is added to constant $T_{\text{Cu}^{II}}^0$. Under these conditions a linear variation of D_0

with $T_{\text{CN}^-}^0$ was observed for $T_{\text{CN}^-}^0 < T_{\text{Cu}^{II}}^0$, the practical experimental range, thus indicating that the violet species is CuCN^I

and that little copper(II) is stored in the complex.

CYTOLOGY OF MEGASPOROGENESIS AS A BASIS FOR STERILITY IN AUTOTETRAPLOID SWEETCLOVER, *MELILOTUS ALBA*¹

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Artificial production of autotetraploid plants is a useful tool in crop improvement programs. Experimentally produced autotetraploids may have desirable agronomic characters, but they usually are significantly lower in fertility than their diploid progenitors. In crops that are normally asexually reproduced, reduced seed production may not necessarily limit utilization of autotetraploid forms. In crop plants that are propagated by seeds, reduction in fertility may be an important limitation to ultimate agronomic utilization.

The production of mature viable seed is determined by a complex series of morphological and cytological processes. Varying degrees of abnormality in one or more critical processes may produce different levels of sterility. From a standpoint of increasing seed production by raising fertility levels, a breeding program can be outlined more intelligently if the cytological behavior of the species is understood.

The cytological basis for low-fertility is known in different experimental autotetraploids. The present investigation was undertaken to determine the cytological basis of seed failure in autotetraploid sweetclover, *Melilotus alba*, which was developed by colchicine treatment. This study included meiosis in the megasporocyte and embryo sac development. Two lines that had relatively high self-fertility and two lines of low self-fertility were used. Fertility levels were based on the production of viable seed after hand-pollination, under greenhouse conditions.

Flower-buds from very young racemes were collected for the most part. Meiotic stages were most abundant in young flowerbuds in which pollen was just changing color from green to yellow. The most numerous figures were obtained from the ma-

terials collected between 9:30 A.M. and 10:30 A.M. in full sunlight, in January and February. Materials were embedded in paraffin and sections were cut eight microns in thickness. Sections of 12 to 20 flowers were mounted on a slide.

Cytological study of meiosis revealed frequent meiotic irregularities. The sporocyte seems to be normal during prophase I, but early prophase cannot be analysed profitably because of the large number of very small chromosomes. During late prophase, as the chromosomes become shortened and thickened progressively, bivalent, quadrivalent, and occasional univalent and trivalent associations have been observed.

Metaphase figures exhibit various abnormalities. Chromosomes are not always oriented on the metaphase plate but are scattered irregularly toward the polar regions of the spindle, or they lag outside the spindle. In addition to more common bivalents, univalents also occur frequently at metaphase I. In some other cases chromosomes are clumped into a deeply stained mass.

Normal anaphase separation is comparatively rare, especially in low-fertility lines. The presence of lagging chromosomes characterizes most of the anaphase figures examined in this study. The extent of lagging varies greatly. In some cells one or two laggards are present, whereas in other cells three or more laggards occur. Some of the laggards may be near the polar groups, or they may be outside the spindle. In addition to frequent lagging in anaphase I, other chromosome aberrations have been observed. In low-fertility lines irregular scattering of the chromosomes of one of the polar groups is frequent. Chromosome clumping is also common in anaphase I. Lagging chromosomes are also evident in telophase I. Highly abnormal chromosome distribution may produce as many as six to seven laggards. Other cells exhibit only one or two lagging chromosomes. In a few cases stray chromosomes occur beyond an interphase nucleus, outside the spindle. This situation

1 a. Chairmen of Committee, J. S. Sass, Dept. of Botany, and I. J. Johnson, Dept. of Agronomy.

b. Doctoral Thesis No. 1282. Submitted June 5, 1952.

2 a. B.S., University of Allahabad, Allahabad, India, 1948.

M.S., Iowa State College, Ames, Iowa, 1951.
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seems to arise from the frequent presence of non-oriented chromosomes at metaphase.

Lagging or non-orientation of chromosomes is also evident in metaphase II. Various chromosome aberrations also occur in anaphase II. Laggards occur in one of the cells or in both cells. In some ovules one of the nuclei of the diad may undergo normal anaphase II division but the other nucleus may fail to divide. This inactive nucleus may be clumped in a single heavily stained mass, or its chromosome complement may be in three to four compact, deeply stained groups. Anaphase separation in two nuclei of the diad is not always simultaneous.

Irregular chromosome distribution is of more frequent occurrence in low-fertility than in high-fertility lines. The low-fertility lines commonly exhibit extreme meiotic irregularities, which seem to be associated with subsequent embryo sac abortion. Scattering of chromosomes of one polar group during anaphase I, also was observed in the two low-fertility lines studied. Abnormality in metaphase, primarily the presence of univalents and non-oriented bivalents, appears to be of common occurrence in both low- and high-fertility lines. Clumping of chromosomes was more frequent in the low-fertility than in high-fertility lines.

A total of 255 dividing cells were examined at anaphase and telophase of both divisions and 183 cells (71.76 per cent) were found to have meiotic irregularities. Of the total number of dividing cells, 102 were from high-fertility lines, 57 of which exhibited irregular chromosome distribution; and 153 were from low-fertility lines, 126 of which were found to have irregu-

larity in chromosome distribution. It is evident that the majority of the irregular and abnormal separations were observed in the two low-fertility lines.

Mitotic anaphases of somatic cells of the ovule and ovary also exhibited lagging chromosomes. This mitotic abnormality leads to the exclusion and irregular distribution of chromosomes in the dividing somatic cells. In some young ovules, hypodermal cells, from which the sporocyte is derived, were found to have mitotic abnormalities.

The present cytological investigation indicates that meiotic irregularity in the ovule is a significant factor in the observed reduction of fertility in autotetraploid sweetclover. Various meiotic abnormalities, primarily lagging and exclusion of chromosomes, lead to the formation of unbalanced gametes and cause different degrees of sterility.

Irregular meiotic behavior seems to be correlated with different levels of sterility. This relationship suggests the possibility of selection for increased fertility levels in autotetraploid sweetclover.

The observed mitotic abnormalities, primarily lagging and exclusion of chromosomes, may give rise to abnormal sporocytes. The sporocyte is derived from the hypodermal cells of an ovule, and any mitotic irregularities in these cells may ultimately produce unbalanced megasporocytes. Subsequent meiotic irregularities increase the opportunities for the formation of aborted embryo sacs and unbalanced gametes. All of these factors lead to the ultimate expression of different degrees of sterility in autotetraploid sweetclover.

PREDICTION OF ACHIEVEMENT OF NATIVE STUDENTS IN ENGINEERING AT IOWA STATE COLLEGE¹

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The problem of survival-attrition is an ever-recurring issue for those charged with

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- b. Doctoral Thesis No. 1202. Submitted July 27, 1951.
- 2 a. A.B., Peru State Teachers College, Peru, Neb., 1942.
- M.S., Iowa State College, Ames, Iowa, 1948.

the responsibility of engineering education. The present study was limited to engineering freshman students who entered the Iowa State College without any prior college experience. Such students were designated as native engineering students. In order that the group chosen might have had an opportunity to graduate, the 1943

native freshman engineering students at the Iowa State College were chosen for study.

In 1946 there were 931 such native engineering students who enrolled, with three out of four being veterans of World War II. Of these 931 students, 280 later graduated in engineering. Thus, judging from the evidence in 1946, the number of freshman engineering students will be reduced from ten to six before a definite curriculum choice is made, and further reduced to three students who will be later graduated from an engineering curriculum.

Of the 931 freshmen entering in 1946, 883 had records complete with respect to the usual prematriculation evidence assembled from the American Council on Education Psychological Examination Quantitative Test, the American Council on Education Psychological Examination Linguistic Test, the Iowa State College Silent Reading Test—Reading Speed, the Iowa State College Silent Reading Test—Reading Comprehension, the United States Armed Forces Institute Test on Correctness and Effectiveness of Expression, College Level—English Placement Test, the Iowa State College Mathematics Placement Test, and the high school grade point average.

Of these 883 students, 529 survived to the fourth quarter in engineering, 264 graduated in an engineering curriculum, and 132 graduated in engineering with an all-college grade point average of 2.50, or better, which for purposes of this study was designated as graduation in the upper half of the class.

It was a major purpose of this study to improve the forecasting of any given student's probability of attrition-survival which might be gleaned without a consideration of individual differences in student capacity, student interests, and student motivation. Attrition-survival in engineering, like that of any other curriculum, depends to a large extent upon these individual differences.

For the purpose of this study, the variables used for prediction of attrition-survival were those assembled as a result of administrative routine at the Iowa State College consisting of information available at the time of matriculation, grade point average at the end of the first quarter in engineering, and achievement in the common sequence courses required of all freshman engineering students.

The prematriculation information available consisted of the previously mentioned

variables assembled at the time of matriculation at the Iowa State College. The grade point average for the first quarter was derived, with few exceptions, from the marks reported in chemistry, engineering drawing, English, general engineering problems, and mathematics courses required of all freshman engineering students during the first quarter in residence. Achievement in freshman engineering courses was also used as a predictor of graduation. This achievement was defined as the sum of the marks made in the usual common sequence courses throughout the freshman year.

Three survival-attrition criteria were chosen for analysis in this study; (1) probability of beginning the fourth quarter in engineering, (2) probability of graduation in engineering, and (3) probability of graduation in engineering in upper half of class.

The probability of survival to the fourth quarter in engineering was 60 chances in 100 when individual differences were ignored. When prematriculation information was utilized these probabilities could be made to vary from 30 chances in 100 to 82 chances in 100, depending upon the score a student made on the American Council on Education Psychological Examination Quantitative Test and the high school grade point average. The probability of survival was somewhat greater for veteran than for nonveteran students. A probability table was developed, showing separate entries for veteran or nonveteran students, utilizing various scores on the American Council on Education Psychological Examination Quantitative Test and the high school grade point average.

Whenever it is possible to delay the forecasting until the end of the first quarter in engineering, the grade point average made during this first quarter may be utilized and all prematriculation information disregarded.

Of the 883 native engineering freshmen of 1946, 264 graduated in an engineering curriculum. Thus, any given individual entering engineering, disregarding individual differences, has 30 chances in 100 of graduating in engineering. When the prematriculation information was considered, it was possible, by means of using the American Council on Education Psychological Examination Quantitative Test score and the high school grade point average, to assign probabilities more sensitively. The chances in 100 for any given student were shown in a probability table

and varied from 9 to 57 chances in 100, depending upon a student's ability as revealed by this prematriculation information.

Whenever possible to postpone the forecasting of probability of graduation until the end of the first quarter, it was found more advantageous to use the first-quarter grade point average, disregarding the prematriculation data. It was found even more satisfactory, when possible to delay forecasting until the common freshman sequence courses had been completed, to use these variables disregarding both prematriculation data and first-quarter averages. It was also found that, for all practical purposes, prediction of graduation could be made satisfactorily by considering the achievement in the freshman chemistry and mathematics sequence courses, disregarding the other three courses common to the freshman curriculum. Thus, instead of indicating that a student's probability of graduating in engineering was 30 chances in 100, it was possible to take into account individual differences in mathematics and chemistry achievement and have these chances vary from 20 to 82 in 100.

A probability table was also developed indicating the chances in 100 of a student graduating in engineering in the upper half of his class. Based upon the American Council on Education Psychological Examination Quantitative Test score and the high school grade point average, the chances in 100 varied from 3 to 35 from the poorest to the best scholastic risk. Should individual differences in student ability be ignored, an over-all probability of 15 chances in 100 of graduation in the upper half of the class would be assigned to each student.

Whenever it was possible to delay such prediction until the end of the first quarter, prematriculation information may be disregarded and the grade point average at the end of the first quarter may be used. The probability of graduating in engineering in the upper half of the class varied from 6 to 30 chances in 100, depending upon the grade point average.

Whenever the prediction of graduating in the upper half of the class may be

delayed until the end of the first year of engineering experience, prematriculation information and first-quarter averages may be disregarded and the probabilities estimated from achievement in the chemistry and mathematics sequence courses required during the freshman year. The probability of graduation in engineering in the upper half of the class varied from 6 to 62 chances in 100 when the chemistry and mathematics marks for the freshman year were considered.

Although this study primarily was concerned with survival, engineering survival-attrition should not be regarded as success-failure, either from the standpoint of the student or from the standpoint of the Iowa State College. Many students who were attrition from engineering later graduated in some nonengineering curriculum. It may be that many of the students here classified as engineering attrition profited from experiences at the Iowa State College, either in the Engineering Division or elsewhere, even though their college careers were not terminated with a baccalaureate degree.

It is possible in counselling freshman engineering students, judging from survival-attrition ratios here reported, to indicate that 60 per cent will survive to the fourth quarter, 30 per cent will graduate in engineering, and 15 per cent will graduate in engineering in the upper half of the class. Such probabilities are based upon the assumption that no information is available concerning the individual differences existing among students.

More satisfactory counselling can be done when individual differences are taken into consideration. This study would suggest that probabilities of survival-attrition be based upon the American Council on Education Psychological Examination Quantitative Test scores and the high school grade point average if prediction is to be made at the time of admission; upon the first-quarter grade point average if prediction is made at the end of the first quarter; and upon the achievement in the chemistry and mathematics sequence courses if prediction is delayed until the completion of the common sequence courses taken during the freshman year.

MARKET NEWS DISSEMINATION IN IOWA¹

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Department of Economics and Sociology

The purposes of this study are (1) to determine how Iowa farmers get market news, (2) to determine how they would like to change market news, and (3) to propose market news dissemination improvements that would place more nearly perfect market information in the hands of farmers. This study is the result of a survey of 600 Iowa farmers in April and May 1949. The study deals with ways farmers used hog, cream or egg market news in their most recent sale of these products prior to their interview.

Farmers may get varying qualities of market information for each commodity by listening to radio, reading newspapers and telephoning buyers. Ninety-eight per cent of these farmers had radios. Ninety per cent took daily newspapers and 84 to 87 per cent had telephone service at their farms.

A. How Farmers Marketing Hogs Obtained Market News

Nearly all the farmers who marketed hogs listened to radio market news from day to day before selling. Half read newspaper market news and nearly half phoned buyers for advice the day they sold hogs.

Those who listened to radio listened to market reports about twice a day. Forty-three per cent listened to the noon farm program on WHO, Des Moines. The second and third largest numbers listened to two WOI, Ames, programs at 10:30 a.m. and 9:45 a.m. daily. All three programs contained interior and terminal hog market news.

Most listened to hog markets at noon. About half listened to hog market news between 8:34 a.m. and 11 a.m., the early hours of trading on most markets.

Sixty-seven per cent of the hog sellers had someone listen to hog market news for them when they could not be at a

radio. This is considered indicative of the emphasis hog farmers place on getting radio market news.

Half the hog sellers read market news in daily newspapers. They mentioned reading market news in 29 daily newspapers. Sixteen per cent named the Des Moines Register.

Seventy-nine per cent of the hog sellers said they paid attention to the reports of terminal hog markets and sixty-eight per cent paid attention to interior hog market reports. Half paid attention to two or more markets when preparing to sell hogs.

Less than half the farmers selling hogs phoned buyers the day of sale. Two-thirds of those called just one buyer that day.

Eighty-six per cent of the hog sellers said radio was the "way of getting market news . . . depended on most."

B. How Farmers Marketing Cream and Eggs Used Market News

Only a few farmers selling cream or eggs referred to market news during the month prior to interview. Twenty per cent of the egg sellers and less than ten per cent of the cream sellers listened to radio market reports on those products. Less than a tenth of either group read market news or called buyers for market information.

Of those who listened, most listened at noon. A few listened to mid-morning reports.

Farmers mentioned getting cream and egg information from 21 daily newspapers, but none more than another.

About 30 per cent paid attention to local cream and egg market prices. Sixteen per cent of the egg sellers and ten per cent of the cream sellers paid attention to terminal market prices.

When asked what way of getting marketing information they depended on most over 50 per cent said they depended on no source. Ten to fifteen per cent of the cream sellers mentioned either neighbors and businessmen, newspapers or radio. About a quarter of the egg sellers depended most on neighbors and businessmen for market information. Under 20 per cent

1 a. Chairman of Committee, Geoffrey Shepherd, Dept. of Economics and Sociology.

b. Doctoral Thesis No. 1216. Submitted September 28, 1951.

2 a. B.S., Iowa State College, Ames, Iowa, 1939. M.S., *ibid.*, 1940.

b. Assistant Professor, Agricultural Experiment Station, Industrial Science Research Institute.

depended most for market news on phone calls to egg buyers or radio.

C. Kinds of Market Reports Preferred

Sixty-seven per cent of the farmers who marketed any of six commodities said they preferred a radio or newspaper report which provided a "complete summary of the market, including top, range and lows." The complete summary would be most likely to give farmers information on the particular product and grade they have for sale.

Eighteen per cent of all farmers said they preferred a radio or newspaper report which tells the "price range for the grade making up the bulk of sales." Ten per cent preferred a report of the "top price for the day on a single market or the top market."

D. Farmers' Suggestions for Changing Market News

Twelve per cent of the farmers wanted market reports on more grades, more commodities or more market points including local markets near their farms. A few wanted more explanations of change in market prices.

Some requested earlier market news broadcasts and summaries at noon or night. A few said newspapers and radio should be more accurate, more understandable and provide more up-to-date reports.

E. Proposed Improvements in Market News Dissemination

Certain suggestions for improving market news dissemination were developed from the study.

1. Complete market news

The reports should: (1) Cover all commodities sold in the coverage area of the medium. (2) Cover all grades and weight classes of the commodities reported. (3) Cover all market places where farm products from the area are sold, including terminal markets as well as local buyers and processing plants. (4) Cover supplies of products on sale, volume sold, prices paid and changes in prices paid during marketing day. (5) Cover the feedstuffs market. (6) Cover wholesale meat trade.

2. Radio stations

One large coverage radio station in every area should broadcast complete market news for all markets serving the area. One

small coverage radio station in every town should broadcast local market reports.

The broadcasts should be scheduled: (1) the same time every day, (2) as early and as often as the broadcaster can depend on getting fresh market news, and (3) when farmers would not be listening to another market news broadcast on like products.

Reports should be read in an accurate and understandable manner in such order that all markets on one commodity are reported before the next commodity report begins.

3. Daily newspapers

Complete terminal, interior and local market news should be published by each of the daily newspapers since 80 per cent of the daily newspaper subscribers among farm operators take but one daily newspaper.

Newspapers should use tabular form showing all markets for one commodity or grade on one line as well as text or narrative copy for market trend information.

4. Other media

Weekly newspapers should publish general market reviews along with current local market prices.

Government mimeographed market reports should be modernized and add explanations of changes in market conditions where possible. Their availability should be publicized to increase circulation.

FM radio facsimile is suggested for Federal and Federal-State Market News Service operation using the facilities of existing FM stations. This would involve sending the market reports to farmers' FM facsimile receivers over supersonic radio waves while normal audible FM radio programs are in progress. In 1950, FM stations were located in Iowa in such a way that FM facsimile could have reached the equivalent of all farmers in 84 of Iowa's 99 counties. Facsimile would give all farmers identical market information in permanently readable form. If the market news services used this method they would know that farmers were receiving all the information prepared for them.

Televised views of cattle sold at terminal markets are suggested. Television may also be used to show line graphs of trend information.

It is anticipated that the adoption of any or all of these measures would provide more nearly perfect market information for farmers.

FARMING STATUS AND READING PREFERENCE IN A MAGAZINE-TYPE PUBLICATION PRESENTING FARM INFORMATION¹

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The effective dissemination of information to farmers is a problem of major concern and is subject to continuous evaluation. To a large extent such re-evaluation has been based upon subjective considerations of the publishers. The present study was designed to furnish some evidence to those charged with the publication of one such magazine—the *Iowa Farm Science*—concerning the reader preferences with respect to content as well as method of presentation and their relationship to such factors as age, education, farming status, and source of farm income.

Questionnaires were mailed to 3,582 readers of the *Iowa Farm Science* who had designated their occupation as farming and 3,101 questionnaires were returned in usable form.

The age and source of farm income of the readers were found to be similar to that of the rural male population of Iowa. However, the educational level appeared to be higher than that of the average Iowa farmer, the mean grade level being approximately eleven years.

The farming status of the readers was similar to that of the Iowa farm population, although there was some slight tendency for fewer tenants to be found in the present study than would be expected from the number of tenants in the Iowa farm population.

Of the 86.6 per cent who responded, a separate analysis was made of those who responded early and those who responded as a result of a follow-up. Some differences were noted, particularly with respect to age, education and source of farm income. Although these differences were significant, they were not unusually large, suggesting that the interpretations made on the basis of the 86.6 per cent who returned questionnaires would be similar if the

group had consisted of the complete list of the farm readers.

The responses of “more,” “less” and “same amount” of *Iowa Farm Science* readers were recorded on ninety-one topics based on twenty-eight subjects dealing with material that had previously been published in the magazine.

Landlords in the present sample were only mildly interested in such hog topics as market hogs, feeding the sow and litter, hog breeding and equipment. The landlords wanted significantly less space devoted to these topics. Their response would indicate, perhaps, that many of them were farming on a cash grain basis and were, therefore, not as interested in such livestock information as were the other readers. On the other hand, tenants wanted significantly more space devoted to a discussion of these hog topics. The tenants undoubtedly look upon hogs as a mainstay in their farming program and would therefore be inclined to show more interest in the enterprise.

In the area of beef cattle enterprise, the readers whose major source of farm income was predominantly beef-hog wanted significantly more information on beef cattle topics. As would be expected, readers whose major source of income was primarily dairy-hog in nature, indicated a desire for significantly more information about dairy cattle.

A majority of the readers indicated a desire for more or the same amount of space devoted to crop rotations and soil erosion. However, readers did not differ from one farming area to another or on the basis of their farming status when preferences to these topics were analyzed. Cash grain farmers did indicate a significantly higher interest in crop rotations than did other farm income groups. They also asked for more information dealing with soil drainage.

The popularity of the foregoing topics and such topics as small grain, fertilizers, grasses and legumes, corn and weather, as shown by the uniformity of requests for more or the same amount of information,

1 a. Chairman of Committee, James E. Wert, Dept. of Vocational Education.

b. Doctoral Thesis No. 1217. Submitted September 28, 1951.

2 a. B.S., Utah State Agricultural College, Logan, Utah, 1943.
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would indicate the merit of continuing to publish numerous articles along these lines.

Many significant relationships were demonstrated when the characteristics of the readers were compared on the basis of reading preferences regarding farm management topics and topics dealing with the sociological development of the farm reader and his family. Tenants indicated a desire for significantly more information about land prices. They were also more interested in reading material concerning landlord-tenant problems. Such a response indicates the tenant's over-all interest in editorial material which aids him in getting more firmly established in farming. Landlords and full owners wanted significantly less space devoted to landlord-tenant problems.

Readers indicating a high degree of interest in school taxes were significantly older readers. Those who wanted more information about state welfare programs, farm legislation and taxation were also significantly older readers than those who wanted lesser amounts. Editorial material about community organizations seemed to attract the younger readers.

The editors of *Iowa Farm Science* were also concerned about the role that education and age played in determining the reader's preference for method of presentation of farm information. In other words, did the reader want his information in the form of text, tables, or graphs? When

reading preferences were analyzed, those who preferred tables rather than text were found to possess a significantly higher educational level than the other readers. On the other hand, the readers who seldom or never read tables had a lower educational level.

Readers who indicated they seldom read graphs if the information was in the story were no different than the other respondents so far as education and age were concerned. Those who would rather get their farm information in a graph than in a table had a significantly higher educational level.

In many of the analyses, significant differences which were apparently related to either age or education disappeared whenever the age or educational level of the reader was controlled. Based on such evidence, any further attempts by the magazine to determine relationships between reader characteristics should not disregard the age-education relationship here demonstrated.

It would appear from the evidence found in the present study, that the editors of *Iowa Farm Science* are doing a commendable job of satisfying the preferences of the farm reader. Although differences among the present group of readers have been demonstrated, such differences do not assume sufficient magnitude to warrant any other than minor changes in the present editorial policy of the magazine.

SELECTION INDEXES FOR RANGE RAMBOUILLET, COLUMBIA AND TARGHEE LAMBS¹

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A perplexing problem in selecting breeding stock is how much importance to attach to each of the several biological traits which contribute to an animal's breeding value. The present investigation was aimed at constructing selection indexes in which information about weanling traits could be used with maximum efficiency to pre-

dict the breeding values of range lambs.

Data were available on 1,080 unselected Rambouillet (Ram₂), Columbia (Col.), and Targhee (Tar₁) lambs of mixed ancestry reared near Cedar City, Utah, on mountain ranges owned by the Utah Agricultural Experiment Station. Among the seven traits observed on each lamb, staple length and weaning weight were measured, whereas type of birth was recorded as single or twin. Face cover, body type, condition (fatness), and skin folds were scored, using a scale ranging from 1 for most superior to 5 for most inferior lambs.

1 a. Chairman of Committee, L. N. Hazel, Dept. of Animal Husbandry.

b. Doctoral Thesis No. 1262. Submitted March 18, 1952.

2 a. A.B., Brigham Young University, Provo, Utah, 1943.
M.S., Utah State Agricultural College, Logan, Utah, 1949.

Superior lambs had long staples, high weaning weights, open faces, good mutton conformation (body type), high condition, no skin folds, and were born as twins.

Environmental and physiological effects for which the traits were corrected were year, age of dam, type of rearing, sex, breeding, and age of lamb. The traits which appeared to be least influenced by these effects were face cover and folds. The trait most influenced was weaning weight.

Phenotypic correlations between folds and weaning weight, folds and body type, and folds and conditions in the Ram₂ lambs were the only phenotypic correlations which indicated impediments to improving all traits simultaneously.³ The traits which were by far most highly correlated with one another phenotypically were weaning weight, body type, and condition. Correlations among these latter traits ranged from 0.47 to 0.73 (all positive with regard to merit).

Genetic correlations between weaning weight and staple length and between weaning weight and folds indicated that simultaneous genetic improvement in these traits would be obstructed to some extent. The largest genetic correlations, ranging from 0.43 to 0.74 (all positive with regard to merit), were those between body type and condition, weaning weight and condition, and staple length and folds. The genetic correlations occasionally had different signs and frequently had widely different magnitudes than the corresponding phenotypic correlations.

Heritability of face cover, folds, staple length, and weaning weight in each group of lambs was sufficiently high to make mass selection for these traits reasonably effective. Heritabilities ranged from 0.78 for face cover down to 0.25 in one instance for folds. Because of the low heritabilities of condition, body type, and type of birth, mass selection for these traits seemed likely to be only slightly effective. Heritabilities ranged from 0.29 for condition down to 0.10 in one instance for type of birth.

Although the evidence was not entirely conclusive, weaning weight seemed to be the trait of greatest economic importance. It was several (four to nine) times more important than body type, condition, folds, and type of birth, all of which seemed to be roughly equivalent in economic importance. Face cover was about equal in importance to weaning weight in the more wool-blind Ram₂ lambs but was of much

less importance than weaning weight in the more open-faced Col₂ and Tar₁ lambs. Staple length was approximately twice as important economically as body type, condition, folds, and type of birth but less than half as important as weaning weight. The relative economic importance of each trait was based upon the estimated increase in net income resulting from one genetic standard deviation improvement in the trait.

To achieve maximum efficiency in estimating over-all breeding value, using the six traits for which complete information was available, one should place the following relative emphasis upon one standard deviation in each trait (emphasis is relative to that for weaning weight):

1. For Ram₂ lambs—face cover, -2.589; staple length, 0.592; weaning weight, 1.000; body type, 0.176; condition, -0.519; folds, -0.002.
2. For Col₂ and Tar₁ lambs—face cover, -0.409; staple length, 0.117; weaning weight, 1.000; body type, 0.129; condition, 0.232; folds, -0.070.

The genetic change expected in each trait as a result of selecting the 38 per cent of the population having the highest index values is as follows:

1. For Ram₂ lambs—face cover, -0.48; staple length, 0.36; weaning weight, 1.71; body type, -0.06; condition, -0.11; and folds, -0.09.
2. For Col₂ and Tar₁ lambs—face cover, -0.17; staple length, -0.13; weaning weight, 3.75; body type, -0.02; condition, -0.05; and folds, -0.01.

The changes are expressed in scoring units for all traits except staple length and weaning weight. The units for the latter two traits are sixteenths of an inch and pounds, respectively.

Including information on type of birth seemed unlikely to increase the efficiencies of the indexes significantly. Omitting folds, body type, and condition from the Ram₂ index and folds, staple length, and body type from the Col₂-Tar₁ index did not reduce appreciably the efficiency of either index. Genetic changes expected in the traits were altered only slightly by the omission of these traits.

The information most needed to improve the reliability of the indexes in their present form was (1) more accurate evidence concerning the magnitudes and signs of the genetic correlations, and (2) more precise information about the relative economic importance of each trait. The additional information most needed to improve the efficiency of the indexes in pre-

³ Estimates of the phenotypic and genetic correlations involving type of birth were not obtained.

dicting over-all breeding value was that concerning fleece weight and grade.

General applicability of the results seemed to be restricted to herds characterized as follows: (1) herds in which the annual weaning percentages are near or above 100 per cent; (2) herds in which the breeding is predominantly Rambouillet or of Rambouillet origin; (3) herds in which little or no inbreeding has occurred; and (4) herds in which the mean and variation of each trait (particularly face cover and weaning weight) are reasonably comparable to the corresponding estimates obtained in this investigation.

The indexes were expected to be most helpful under the more usual range conditions if lambs were segregated at weaning age into separate groups in each of

which the important environmental and physiological effects (such as age of dam, type of rearing, etc.) were the same for all members. An equivalent proportion of individuals would then be selected from each group, emphasizing one standard deviation in each of the three most important traits (in each index) as follows:

1. For Ram₂ lambs—face cover, -2.125; staple length, 0.457; and weaning weight, 1.000.
2. For Col. and Tar. lambs—face cover, -0.447; condition, 0.259, and weaning weight, 1.000.

Selection might be accomplished with reasonable acumen under these circumstances on a visual basis, although such selection is not likely to be as effective as that based on index values calculated arithmetically.

SOME COMPARISONS OF DIBENZOFURAN AND DIBENZOTHIOPHENE TYPES¹

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A survey of the literature was made for the purpose of comparing the metalation, oxidation, halogenation, nitration, and selected condensation, rearrangement, and reduction reactions which have been carried out with dibenzofuran, dibenzothiophene, phenoxathiin, thianthrene, and dibenzo-*p*-dioxin. A critical examination of the survey revealed that many of the comparisons were severely limited by a lack of experimental data. The purpose of this study was to obtain the data needed for more complete comparisons of some of the reactions and orientations of oxygen- and sulfur-containing heterocycles.

The reaction of lithium with dibenzofuran and dibenzothiophene in dioxane and ether solutions was investigated. Cleavage of dibenzofuran occurred in both solutions, but dibenzothiophene reacted appreciably only in dioxane. Both carbonation and hydrolysis of the dioxane reaction mixtures yielded *o*-hydroxydiphenyl (80 per cent yield) in the case of dibenzofuran and *o*-mercaptodiphenyl (m.p. 40-41°, 36 per cent yield) and diphenyl (42 per cent

yield) from dibenzothiophene. When ether was used as the solvent for the reaction of lithium and dibenzofuran, however, carbonation gave 3,4-benzocoumarin (the lactone of 2'-hydroxy-2-diphenylcarboxylic acid) melting at 95-96° (47 per cent yield).

A qualitative comparison showed *n*-propyllithium to be a better metalating agent than *n*-butyllithium for the preparation of 4-dibenzothiophenecarboxylic acid. *n*-Butyl 4-dibenzothiophenyl ketone (m.p. 116-117°) was identified as one of the carbonation by-products from the reaction of dibenzothiophene with excess *n*-butyllithium.

Attempts to dimetalate dibenzothiophene with *n*-butyllithium, *n*-butylsodium, and benzylsodium were unsuccessful. The failure of dimetalation to occur was somewhat surprising since dibenzofuran is dimetalated in over 70 per cent yields in corresponding reactions.^{3,4}

The metalation of diphenyl sulfone and dibenzothiophene-5-dioxide with *n*-butyllithium was successfully accomplished by using temperatures of -20° to -30°. In both cases the use of only one equivalent

1. Chairman of Committee, Henry Gilman, Dept. of Chemistry.

b. Doctoral Thesis No. 1234. Submitted December 12, 1951.

2. B.A., Dakota Wesleyan University, Mitchell, S.D., 1946.

b. Assistant, Industrial Science Research Institute.

3. H. Gilman and R. V. Young, *J. Am. Chem. Soc.*, 56, 1415 (1934).

4. H. Gilman and R. V. Young, *ibid.*, 57, 1121 (1935).

of *n*-butyllithium gave monometalation, whereas the use of two or more equivalents of the organometallic compound yielded dimetalated sulfones. The compounds obtained were 4-carboxydibenzothiophene-5-dioxide melting at 337-338°, 4,6-dicarboxydibenzothiophene-5-dioxide melting at 394-395°, *o*-carboxydiphenyl sulfone melting at 146-147°, and *o,o'*-dicarboxydiphenyl sulfone melting at 220-221°. Attempts to extend the metalation at reduced temperatures to diphenyl sulfoxide led to a cleavage reaction from which the only product identified after carbonation was benzoic acid.

4-Hydroxyphenoxathiin (m.p. 98-99°), 1-hydroxythianthrene (m.p. 117-118°), and 4-hydroxydibenzofuran (m.p. 99-100°) were prepared by treating the corresponding organolithium compound with oxygen in the presence of a molar equivalent of *n*-butylmagnesium bromide. The 4-hydroxydibenzofuran was successfully chlorinated with sulfur chloride to yield either 1-chloro-4-hydroxydibenzofuran melting at 154-155° or 1,3-dichloro-4-hydroxydibenzofuran melting at 160-161°.

Hydrogen peroxide was established as being a satisfactory reagent for the oxidative preparation of dibenzothiophene-5-oxide (m.p. 186-187°), dibenzothiophene-5-dioxide (m.p. 232-233°), phenoxathiin-10-oxide (m.p. 152-153°), phenoxathiin-10-dioxide (m.p. 147-148°), 4-bromodibenzothiophene-5-dioxide (m.p. 202-203°), 2,8-dibromodibenzothiophene-5-dioxide (m.p. 360-361°), 4-carboxydibenzothiophene-5-dioxide (m.p. 337-338°), 4-dibenzothiophenecarboxamide-5-dioxide (m.p. 236-238°), and *o,o'*-dicarboxydiphenyl sulfoxide (m.p. 310-311°) and sulfone (m.p. 220-

221°). The melting point of 220-221° observed for the *o,o'*-dicarboxydiphenyl sulfone did not agree with the value of 137° reported in the literature.⁵

2,8-Dibromodibenzothiophene was prepared by an improved procedure and nitrated satisfactorily to yield 2,8-dibromo-3,7-dinitrodibenzothiophene-5-oxide melting at 312-313° (56 per cent yield).

Attempts to condense 4-hydroxydibenzofuran with formaldehyde in both basic and acidic media failed. A similar lack of success attended efforts to condense 2,8-dibromodibenzothiophene-5-dioxide and 2,8-dibromo-3,7-dinitrodibenzothiophene-5-oxide with resorcinol in the presence of aluminum chloride.

4-Dibenzothiophenecarboxamide (m.p. 250-251°) was found to undergo the usual rearrangement of the Hofmann reaction to give 4-aminodibenzothiophene melting at 109-110° (48 per cent yield).

The reductive desulfurization of dibenzothiophene derivatives with Raney nickel as a means of structure proof was found to be unsatisfactory when applied to 2-bromodibenzothiophene, dibenzothiophene-5-oxide, and dibenzothiophene-5-dioxide. With 2-bromodibenzothiophene the only product isolated was a small amount of diphenyl. No cleavage product could be obtained from the reaction of Raney nickel with dibenzothiophene-5-oxide or -5-dioxide.

Alkali fusion of 2,8-dibromodibenzofuran when carried out in refluxing dimethoxytetraglycol gave only reductive debromination.⁶

5 F. Mayer, *Ber.*, 43, 584 (1910).

6 H. Gilman, D. L. Esmay and R. K. Ingham, *J. Am. Chem. Soc.*, 73, 470 (1951).

FACTORS AFFECTING THE DURABILITY AND WIND RESISTANCE OF ASPHALT SHINGLES¹

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This study consisted of a composition analysis and an experimental study of

the wind resisting characteristics of a number of tab-type asphalt shingles. It was a part of the over-all Iowa Agricultural Experimentation Project entitled "An Investigation of Farm Building Losses Due to Wind and Fire." Statistical studies of the wind loss experiences since 1930 brought to light the very rapidly increasing trend of wind damage to asphalt shingles on farm buildings in Iowa.

- 1 a. Chairmen of Committee, Henry Giese, Dept. of Agricultural Engineering, and R. A. Caughey, Dept. of Civil Engineering.
- b. Doctoral Thesis No. 1207. Submitted August 18, 1951.
- 2 a. B.S., South Dakota State College, Brookings, S.D., 1942.
M.S., Iowa State College, Ames, Iowa, 1947.
- b. Associate, Agricultural Experiment Station.

Twenty-seven various weights and makes of tab-type asphalt shingles were investigated. They consisted of (1) 14 thick-butt shingles, (2) 7 hex-tab shingles, and (3) 6 uniform-thickness shingles. Composition analysis of the 27 types of shingles from thirteen manufacturers determined the following: (1) weight of the dry felt, (2) amount of felt saturation, (3) amount of top coating bitumen, (4) amount of back coating bitumen, (5) per cent of filler in coating, (6) amount of top surface granules, and (7) amount of back dusting mineral.

A method was developed and a machine designed and constructed for measuring, in the laboratory under controlled conditions, the bending resistance of asphalt shingles.

A factorial experiment was designed for the physical tests of the 27 types of asphalt shingles, in order that they might be tested with six different types of nailing patterns and at three temperature levels. This technique satisfied the primary objective of determining comparative bending resistances of the shingles tested as well as furnishing considerable information on the conditions of application without any loss of precision. The six nailing patterns used were as follows: (1) six nails placed $5\frac{1}{8}$ inches from the butt, (2) four nails placed $5\frac{1}{8}$ inches from the butt, (3) six nails placed $6\frac{1}{8}$ inches from the butt, (4) four nails placed $6\frac{1}{8}$ inches from the butt, (5) six nails placed $4\frac{1}{8}$ inches from the butt, and (6) six nails placed $6\frac{1}{8}$ inches from the butt. The three temperature levels used were (1) 55°F ., (2) 70°F ., and (3) 85°F .

The physical test measurement data recorded consisted of (1) the initial bending resistance, (2) the resistance on each of the successive four bends, (3) the number of bends at bending resistances divisible by five down to a resistance of 10 pounds, and (4) whether the shingle tore past the nail heads in bending or not.

The initial bending resistances as well as the totals of the first five bending forces were used to run an analysis of the variance on the factorial data. A multiple correlation was made between the continued bending resistance and the composition of the various shingles.

From the results and findings of this study, the following conclusions were drawn:

1. From the preliminary analysis of variance of the factorial experiment the following conclusions were drawn:
 - a. Nailing patterns, different than the

standard specifications, affect the bending behavior of thick-butt asphalt shingles far more than either hex-tab or uniform shingles.

- b. Temperature variations affect the bending behavior of hex-tab shingles the most; however, the interaction effect between temperature level and nailing pattern is highest with the thick-butt type shingles.
2. From the detailed analysis of application with different numbers of nails the following conclusions were drawn:
 - a. No advantage in bending resistance is gained with the use of six nails as compared to four in the application of hex-tab and uniform-thickness shingles when nailed not higher than the standard specifications of $5\frac{1}{8}$ inches.
 - b. Six nails per strip shingle are advantageous over four in applying thick-butt shingles, as added assurance against tearing past the nail heads in bending.
 - c. Six nails offer added bending resistance over four with all types of tab-type asphalt shingles when the nails are placed higher than the specified distance of $5\frac{1}{8}$ inches.
3. From the detailed analysis of application with various nailing distances the following conclusions were drawn:
 - a. Higher nailing than the specified $5\frac{1}{8}$ inches for thick-butt shingles is very critical as it results in the nails being placed near, on, or above the weak transition lines.
 - b. Lower nailing of asphalt shingles at the $4\frac{1}{8}$ -inch distance will increase bending resistances about 25 per cent with thick-butt shingles and over 10 per cent with those of uniform-thickness cross sections.
 - c. There is no significant reduction in the bending resistance of uniform-thickness shingles, either hex or square tab, when the nails are placed up to one inch higher than the specified $5\frac{1}{8}$ inches.
4. From the detailed analysis of the effect of temperature level on bending resistance the following conclusions were drawn:
 - a. There is a non-linear relation between bending resistance of asphalt shingles and temperature. The resistance increases at a faster rate as the temperature drops from 70°F . than it increases as the temperature rises from that point.

- b. Lower temperatures cause the bending resistance of thick-butt shingles to drop off more rapidly than the other types because of more frequent tearing failures around the nail heads.
 - c. The advantage in bending performance of uniform-thickness shingles over thick-butt types increases as the temperature drops from 85 to 55°F.
5. From the standpoint of over-all weight of asphalt shingles there is a highly significant correlation between it and the initial bending resistance with a somewhat lower correlation with the resistance after five bends, which indicates that factors other than mere weight affect the ability of asphalt shingles to sustain bending stresses.
 - a. The rate of increase of sustained bending resistance with the addition of weight to asphalt shingles is 2.5 times greater for uniform-thickness shingles than for the thick-butt types.
 6. From the study of the effect of the various constituents of asphalt shingles on bending resistance, the following correlations were derived:
 - a. The effect of the per cent of felt on sustained bending resistance is highly significant and may be represented by the following linear regression equation:

$$Y = 1.0516X + 56.4154$$
 - b. The effect of per cent of filler in the coating and the total portion of mineral matter on sustained bending resistance is significant at the 5 per cent level and may be represented respectively by the following linear regression equations:

$$Y = -0.0872X + 70.8327$$

$$Y = -0.1875X + 76.6672$$
 7. In comparing the over-all wind resisting performance of the various types of asphalt shingles the following conclusions were drawn:
 - a. On a weighted basis the uniform-thickness shingles will resist bending stresses 23 per cent higher initially and 55 per cent higher after five bends than the thick-butt types.
 - b. Uniform-thickness asphalt shingles make more efficient use of the materials from which they are ordinarily manufactured than do the thick-butt types.

EFFECT OF COMBINED PRESSURE AND CONCENTRATION GRADIENTS ON GASEOUS FLOW THROUGH SOILS¹

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The flow of gases due to a combined concentration and total pressure gradient in soil is of importance in several problems dealing with soil aeration. This paper gives a general theory for gas flow when such phenomena are involved.

Before the theoretical development could be justified, it was necessary to determine the law of flow of gases through soils at very low pressure differentials. It was found that Darcy's law was valid down to pressure gradients as low as 0.00018 mm. of water per mm. of porous medium, and

there were indications that the law is valid down to a pressure gradient of zero. Also, the effect of slip flow and free molecular flow was found to be negligible in its effect on Darcy's law as applied to the flow of gases in ordinary moist soil.

A general differential flow equation was derived by adding terms due to the laws of Darcy and Fick. This equation, together with two auxiliary differential equations, was used in solving the flow problems of interest. The solution of the differential equations yielded the quantity of flow, the gas concentration and the pressure distribution for each component of the flowing gas.

As particular applications of the general differential equations, the following five problems were solved: (a) flow through a tube containing a porous medium when there is an absorber at one end which re-

1 a. Chairman of Committee, Don Kirkham, Dept. of Agronomy.
b. Doctoral Thesis No. 1297. Submitted June 9, 1952.
2 a. B.S., Ohio State University, Columbus, Ohio, 1947.
M.S., Iowa State College, 1950.
b. Associate, Agricultural Experiment Station.

moves one component of a gaseous mixture; (b) flow through a similar tube with a volatile liquid at one end; (c) the same as (b) except that the variation in viscosity with gas concentration is to be taken into account; (d) a respiration problem in which carbon dioxide and oxygen are diffusing in opposite directions through soil; and (e) a problem dealing with the importance of mass flow, as compared with diffusion flow, when the barometric pressure is changing linearly with time.

For problem (a) it was found, in a specific example, that the error involved in the measurement of the diffusion coefficient, if a total pressure gradient was not taken into account and diffusion flow only considered, was 13 per cent. In problem (b), with carbon disulfide as the volatile liquid, the error computed in the same manner was 43 per cent. From the results of problem (c) it was concluded that the effect of viscosity changes with concentrations can normally be neglected.

Problem (d) is always present in soil where respiration is occurring. The differences in the rates of diffusion of carbon dioxide and oxygen in soil cause a slight build up of pressure (gauge pressure) in

the soil. But in solving the problem it was found that this pressure build up is small and can generally be neglected in its effect upon gas transfer. The error involved was never greater than 6 per cent for conditions which normally might be found in the soil.

The solution of problem (e) showed that the effect of barometric pressure changes, of magnitude normally expected, will have little influence upon the amount of gas transferred through soil.

In order to test the validity of the general flow equations, some experimental results were obtained for problem (b) when the vapor was carbon disulfide and the results compared with the theoretical. There was a satisfactory agreement.

The theoretical results of problem (b) were compared with theoretical results, for the same problem, given by another investigator. The latter's theory did not take differences in diffusion coefficients of air and vapor into account. The present theory does. It was found that an error of 19 per cent would result in problem (b) if differences in diffusion coefficients of air and vapor were not taken into account. If the vapor is ethyl alcohol, the error would be 3.8 per cent.

ELECTRICAL TRANSIENTS IN WAVE GUIDES¹

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The purpose of this study was to find solutions of some geometrically simple wave guide systems in the transient case, with particular emphasis on waveform preservation. The primary difficulty in these problems is the lack of data on the transient response of antennas. Since all pick-up and energy insertion devices for guides must be considered as antennas, time dependent solutions for these must

be known. Slot antennas are the only ones with simple, known transient solutions, therefore these were the only ones considered. Two types of wave guides were investigated, infinite parallel planes and semi-infinite cylinders. These were excited by slots and solved both with non-dissipative and dissipative media. Infinite conductivity of the bounding surfaces was assumed except for the exciting slots. Receiving or pick-up slots were not included due to the excessive complexity of the resulting expressions arising from reflections.

In the case of the dissipative parallel plane guide, mathematical expressions as illustrated in Equation (1) were found.

$$E_z \Big|_{y=0} = \frac{V_0}{2b} \left(\frac{\epsilon}{\mu} \right)^{1/2} e^{-\left(\frac{\mu}{\epsilon} \right)^{1/2} \frac{\sigma}{2} z} \sin \omega t' u(t') + \frac{V_0}{4b} \frac{\sigma}{(\mu \epsilon)^{1/2}}$$

1. Chairman of Committee, W. L. Cassell, Dept. of Electrical Engineering.

b. Doctoral Thesis No. 1236. Submitted December 12, 1951.

2. a. B.S., University of Oklahoma, Norman, Oklahoma, 1946.

M.E.E., *ibid.*, 1947.

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$$\begin{aligned}
& \cdot \left\{ \int_{z(\mu\epsilon)^{1/2}}^t \sin \omega(t-t_1) e^{-\frac{\sigma}{2\epsilon} t_1} \left[\frac{t_1}{(t_1^2 - z^2 \mu\epsilon)^{1/2}} I_1 \left[\frac{\sigma}{2\epsilon} (t_1^2 - z^2 \mu\epsilon)^{1/2} \right] \right. \right. \\
& \left. \left. + I_0 \left[\frac{\sigma}{2\epsilon} (t_1^2 - z^2 \mu\epsilon)^{1/2} \right] \right] dt_1 + 2 \sum_{n=1}^{\infty} \right. \\
& \left. \int_{z(\mu\epsilon)^{1/2}}^t \left[\omega \cos \omega(t-t_1) + \frac{\sigma}{\epsilon} \sin \omega(t-t_1) \right] \right. \\
& \left. e^{-\frac{\sigma}{2\epsilon} t_1} J_0 \left[\left(\frac{n^2 \pi^2}{b^2 \mu\epsilon} - \frac{\sigma^2}{4\epsilon^2} \right)^{1/2} (t_1^2 - z^2 \mu\epsilon)^{1/2} \right] dt_1 \right\} u(t') \quad (1) \\
& t' = t - z(\mu\epsilon)^{1/2}
\end{aligned}$$

$u(t')$ --- unit step at the origin

This solution was obtained by a double Laplace transformation and two inversions of the resulting expressions. The first inversion was accomplished by residue

theory and the second by the Faltung integral method.

In the dissipative cylindrical guide a typical result is given by Equation (2).

$$\begin{aligned}
E_z &= \frac{2V_0 a}{c^2(\mu\epsilon)^{1/2}} \sum_{i=1}^{\infty} \left\{ q_i J_1(q_i a) \frac{J_0(q_i r)}{[J_1(q_i c)]^2} \right. \\
& \cdot \int_0^{t'} \sin \omega(t'-t_1) e^{-\frac{\sigma}{2\epsilon} [t_1 + z(\mu\epsilon)^{1/2}]} \\
& \cdot J_0 \left[\left(\frac{q_i^2}{\mu\epsilon} - \frac{\sigma^2}{4\epsilon^2} \right)^{1/2} (t_1^2 + 2z(\mu\epsilon)^{1/2} t_1)^{1/2} \right] dt_1 \left. \right\} u(t') \quad (2)
\end{aligned}$$

$$0 \leq r \leq c$$

$$J_0(q_i c) = 0 \quad i = 1, 2, 3 \dots$$

c --- radius of the guide

a --- radius of excitation slot

This solution was obtained by a Laplace transformation followed by a finite Hankel transform. The final inversion was again obtained by convolution. These solutions exhibit attenuation with distance and also in time in the case of certain modes.

Equation (2) has been evaluated in the steady state and for very small values of t' , with an assumed set of system parameters. The steady state predominance of certain modes in the transmission band is not apparent in the transient case. The initial oscillatory nature of the transient response is characteristic of the system and to a large extent independent of the driving frequency.

It was not found possible to calculate the response for all values of time due to the lack of satisfactory methods for evaluation of the complicated integrals as found in Equations (1) and (2). Numerical in-

tegration and series expansions were tried, but all schemes tested proved much too lengthy to be of value. The digital computer seems to be the most promising means for obtaining results for the integrals unless further research discloses solutions in semi-closed forms.

The study succeeded in obtaining results for propagation in wave guides with the solutions expressed in the form of integrals from which the preservation of signal waveforms may be examined. The examinations appear feasible only if a large scale digital computer is available to carry out the numerical analysis. Experimental studies in verification of these theoretical results should become possible as the art of high frequency, instantaneous recording progresses and wave guide dimensions are reduced by the use of high permeability and high dielectric constant materials.

ORGANIC BASES AND OTHER AGENTS FOR AMINO ACID RESOLUTION¹

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Most of the previously reported resolutions of amino acids have required substitution (for hydrogen) of an acyl group on the amino nitrogen atom; the free carboxyl group is then sufficiently acidic to form salts with asymmetric amines or alkaloids whose K_B values do not exceed 10^{-4} . The purpose of this investigation was to evaluate some new procedures which would not require preliminary preparation of any covalent amino acid derivative.

Three difficulties to be surmounted in this task were the following:

1. The existence of monoaminomono-carboxylic acids in a dipolar ion structure with no acidic or basic groups strong enough to form true salts with alkaloids or carboxylic acids, respectively.

2. The tendency of amino acids toward formation of DL-compounds of smaller solubilities than those of pure antipodes;

these precipitate wherever possible in preference to the L- or D-forms.

3. Difficulty of inducing crystallinity in most of the salts prepared in this work.

Partial "salt" formation from amino acids and either aliphatic amines or carboxylic acids has been reported; it seemed desirable to test whether the use of large excesses of an asymmetric amine or carboxylic acid as solvent could overcome the first two difficulties enough at least for partial resolution. However, attempts to crystallize optically active leucine hydrochloride, phenylalanine, methionine, and valine from syrupy L(+) lactic acid; and optically active phenylalanine and valine from (-)2-aminobutan-1-ol led to precipitation of the DL-amino acid compound only. Exploratory trials with cholic acid, nitrocellulose, casein, and cellulose phosphate as asymmetric chromatographic adsorbents also led to no demonstrable difference between D- and L-amino acids in their adsorption behavior.

The main part of this work was concerned with the preparation of salts from amino acids and asymmetric bases strong enough to create an amino acid anion.

1 a. Chairman of Committee, Sidney W. Fox, Dept. of Chemistry.

b. Doctoral Thesis No. 1192. Submitted July 13, 1951.

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During the preparation of these bases and improvement of synthetic methods, the following new compounds were prepared and characterized: (—)2-aminobutan-1-ol (+)bitartrate monohydrate (m.p. 102°); β -dimethylaminoethyl butyl ether bioxalate (m.p. 108°), methiodide (m.p. 75°); β -diethylaminoethyl amyl ether (b.p. 102°/16 mm.), bioxalate (m.p. 85°), ethiodide (m.p. 108°); β -diethylaminoethyl allyl ether (b.p. 67°/15 mm.), ethiodide (m.p. 90°); β -diethylaminoethyl benzyl ether bioxalate (m.p. 103°), ethiodide (m.p. 103°); methylisourea sulfate (m.p. 171°); morpholine carboxamidine sulfate (m.p. 306° (dec.)).

2-Aminobutan-1-ol was resolved by (+)tartaric acid, a method not previously used on this particular amine. The configuration of the asymmetric carbon was retained during the preparation (from 2-aminobutan-1-ol) of five new amines (and derivatives) by the Eschweiler-Clarke dimethylation and the Williamson ether synthesis: (+)2-dimethylaminobutan-1-ol (b.p. 61°/15 mm.), bioxalate (m.p. 117°), methiodide (m.p. 228°); (—)2-dimethylamino-*n*-butyl benzyl ether (b.p. 136°/17 mm.), bioxalate (m.p. 82°), methiodide (m.p. 143°), benzyl bromide addition product (m.p. 124°); (—)2-dimethylamino-di-*n*-butyl ether (b.p. 87°/17 mm.), bioxalate (m.p. 77°), methiodide (m.p. 110-112°); (—)2-dimethylamino-*n*-butyl *o*-chlorobenzyl ether (b.p. 122°/<1 mm.), bioxalate (m.p. 103°), methiodide (m.p. 167°), benzyl bromide addition product (m.p. 124°); (—)2-dimethylamino-*n*-butyl *p*-chlorobenzyl ether (b.p. 127°/1 mm.), methiodide (m.p. 158°), benzyl bromide addition product (m.p. 122°).

In addition to the above quaternary halides syntheses were carried out for phenylethylbrucinium bromide (m.p. 216° (dec.)), γ -phenoxypropylbrucinium bromide (m.p. 201°), (+)2-guanidinobutan-1-ol sulfate (m.p. 183°) and d-bornyl-guanidine sulfate (m.p. 326° (dec.)); all of these new compounds.

Samples of pure D- and L-phenylalanine were prepared by a new resolution starting with formyl-DL-phenylalanine. Combination with (—)2-aminobutan-1-ol in a butanol-hydrocarbon solvent yielded first the salt of formyl-D-phenylalanine (m.p. 129°), then the salt of formyl-L-phenylalanine (m.p. 106°) from the filtrate. The separation was dependent on supersaturation of the latter. Addition of the correct amount of hydrochloric acid to these salts liberated formyl-D- and L-phenylalanine, from which free D- and L-phenylalanine were obtained by known methods.

(—)2-Aminobutan-1-ol was also used to resolve unsubstituted DL-glutamic acid in a new procedure; the salt of D-glutamic acid (m.p. 146°) crystallized from 95 per cent ethanol completely enough so that both D- and L-glutamic acids were obtained pure, from precipitate and filtrate respectively.

The quaternary halides, when treated with moist silver oxide, yielded methanol solutions of quaternary hydroxides, which dissolved the theoretical amounts of D- or L-phenylalanine. In most cases replacement of the solvent by dioxane yielded oils or clear solutions, but a precipitate prepared from methylcinchoninium hydroxide and D-phenylalanine led to the development of a new resolution method. DL-Phenylalanine was dissolved with the stoichiometric quantity of methylcinchoninium hydroxide in methanol; evaporation of methanol and replacement by dioxane yielded methylcinchoninium D-phenylalanine salt (m.p. 174° (dec.)) which was recrystallized four times by the same technique. Treatment of an alcohol solution of this diastereomer with oxalic acid yielded D-phenylalanine in 20 per cent yield.

In experiments wherein addition of dioxane produced only clear solutions, attempts were made to precipitate carbamino salts by addition of carbon dioxide; however, only the free amino acid was obtained.

DEVELOPMENT OF MEASUREMENT TECHNIQUES FOR THE COMPARATIVE SOCIOLOGICAL ANALYSIS OF RURAL COMMUNITIES¹

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On the basis of data collected for a study of the relation of farmers' cooperatives to the Iowa communities in which they were established, three community indexes were developed. The purpose of such indexes was to determine whether or not there were statistically significant differences between communities with cooperatives and communities without them.

The theoretical justification for considering such indexes to be indexes of community was that no index measured all aspects of a phenomenon; it more often measured only one aspect. Therefore, an index which measured some aspect or component of community could be considered an index of community. The components of a primary rural community were considered, by definition, to be: a constellation of institutionalized services, a feeling of interdependence, a feeling of common interest, a sense of belonging to the community group as a whole, a common set of values, and common social norms of behavior.

The business services were the part of the institutionalized services to be measured by the first two indexes. In developing the first index, the Business Service Index, the business agencies of primary rural communities were classified according to six categories: A. communication, B. professional, C. farm supply and marketing, D. commercial recreation, E. civic utilities, and F. general commercial services. The number of agencies in each of these categories was determined for the sixteen community trade centers included in the study of cooperatives in Iowa, and a regression coefficient was computed between the number of agencies and the population of the centers. With this coefficient it was possible to compute the

number of agencies in each category which centers of a certain population could be expected to have. Each community was then scored by the amount its actual number of services differed from the expected number.

The nine community trade centers which had cooperatives possessed Business Service Index scores which were significantly higher than the seven trade centers without cooperatives.

Dun and Bradstreet estimates of the financial strength of the business agencies in the community trade centers were used as the basis of the second index, the Per Capita Financial Strength Index. Fluctuations in money value were eliminated from the total financial strength estimates of each trade center by the use of the Federal Reserve Commodity Price Index figures. Then the corrected total estimate for each center was divided by the population of the center to obtain the per capita estimate.

Per Capita Financial Strength Index scores were obtained for the sixteen community trade centers for the years 1925, 1930, 1935, 1940, 1945 and 1949. An analysis of these data indicated that, in 1925, before cooperatives were established in any of the trade centers, the nine centers which later acquired cooperatives had an average PCFS Index score which was not significantly different from the average for the seven centers which did not acquire cooperatives. By 1949, however, the average for the centers with cooperatives was significantly higher than the average for the centers without cooperatives. The average for the centers with cooperatives was also slightly stronger in 1949 than it had been in 1925 while the average for the other centers was lower than it had been at the earlier date.

These two business indexes are measures of that component of community which is the constellation of institutionalized services as it existed in fact. The third index, the Community Solidarity Index, was designed to measure the degree of satisfac-

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tion with the manner of the functioning of all community services as it was expressed in the opinions of members of the community. This was done by registering the reaction of community members to forty statements relating to eight areas of community behavior: I. community spirit, II. interpersonal relations, III. family responsibility, IV. schools, V. churches, VI. economic behavior, VII. local government, VIII. tension areas. The respondents were given an opportunity to indicate that the statements, as they applied to their respective communities, were very true, true, not applicable, untrue, or definitely untrue.

Included in the components of a primary rural community were a common set of values and common norms of behavior. If such values and norms existed to a high degree in a community, the community members would show a high degree of consensus in their opinions about community behavior. This degree of consensus or solidarity was determined for each community by computing the standard deviation of the scores of all the Community Solidarity Index schedules obtained from community members. If the standard deviation was small, a high degree of consensus or solidarity existed; if it was high, solidarity was less.

A community profile was drawn with the use of the Community Solidarity Index scores. A score of 25 points was possible for each of the eight areas of community behavior. An octagon was drawn with a radius of 25 units from center to each of the points. The mean community score for each area was laid out on the radius of this octagon, with one sigma distance indicated above and one below the mean. When lines were drawn between the means and sigma distance points of all the areas, three octagons took shape upon the base octagon which represented a community with a perfect score. The sym-

metry of the octagons thus drawn indicated whether or not the areas of community behavior were well balanced, and the spread between the upper and lower sigma distances illustrated the degree of agreement present in the community.

In place of a random sample of the adult population the junior and senior students in the high schools of eight of the sixteen communities of the cooperative study were used to pretest the Community Solidarity Index. On the basis of the scores from these schedules it was found that the five communities with cooperatives had significantly higher community scores and a lower standard deviation (indicating more solidarity) than the three communities without cooperatives.

In terms of what they were designed to measure, these three community indexes have been validated by their application to the communities of the cooperative study. All three indexes detected significant differences between communities in regard to certain characteristics which by definition were said to be components of primary rural communities.

All three indexes succeeded in eliminating the influence of community size, in avoiding arbitrary standards of achievement, and in evaluating the community as a social entity apart from environmental factors. The indexes were capable of being administered objectively and were subject to numerical evaluation.

This dissertation did not attempt to evaluate the components of primary rural communities as such. Therefore, the implication cannot be drawn that a high score on any of the indexes developed here is evidence that the community is a superior community, except in the case of the Community Solidarity Index where a high total score indicates that the community is a superior community in the opinion of its own members.

A NITRIFICATION PROCEDURE FOR PREDICTING THE AVAILABILITY OF NITROGEN TO CORN ON IOWA SOILS¹

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Nitrification rate has been proposed as a method for evaluating the nitrogen fertilizer requirement of soils. It is determined by measuring the increase in nitrate nitrogen in a soil sample after a given period of time of incubation at optimum moisture and temperature. Studies were made of some important factors influencing nitrate production in soils. Procedures are proposed in which simple equipment is used for rapid nitrification rate and which requires a minimum of time for analysis.

Maintaining moisture throughout the incubation period is an important factor in nitrate production. The loss of moisture during two- or three-week incubation periods from soil samples in pint milk bottles covered with cheesecloth plugs was found to be quite large. This loss was eliminated when one hole rubber stoppers were used in place of the cheesecloth. Aeration through the one hole stopper was adequate for nitrification.

The optimum moisture for nitrification was found to be a partial function of the method of moisture addition. When water was mixed with the soil, the optimum moisture for nitrification was about 25 per cent for soils medium to high in organic matter and loam to silty clay loam in texture. On soils in which excess water was removed by pressure or tension, the maximum nitrification rate took place at 100 cms water tension. This was equivalent to 25 to 35 per cent moisture in the soils studied.

Sample size had little influence upon nitrification rate when moisture and aeration were controlled. No difference in nitrate production was obtained in incubating 25 or 100 gram samples in milk bottles. In nitrification studies with 10 grams of soil in 30 ml bottles, the results were consistently lower by about 5 ppm than

those from 25 or 100 gram samples in milk bottles.

The type of container had no influence on nitrification rates when one hole rubber stoppers were used to cover them.

Aggregate size apparently had little influence upon nitrate production. Samples mixed by hand to eliminate clods larger than about three-eighths of an inch in diameter had approximately the same nitrification rate as samples crushed to pass 10 or 20 mesh screens.

Several modifications for increasing speed and ease of analysis without sacrificing accuracy were made in the phenol-disulfonic acid procedure for nitrate determination. Specially constructed trays permitted handling 12 samples as a unit. Measured quantities of solutions were added to obtain a given volume rather than bringing the solutions to volume in a volumetric flask. Measurement of the intensity of the yellow color produced was made on a photometer with a calibration curve instead of direct comparison with standard solutions.

Composite soil samples were taken from first- and second-year corn following sweet clover and meadow in the rotation plots at Ames and Clarinda, Iowa. A small difference was found in both nitrate production and initial nitrate content of soil samples taken in May, July and September but on almost all of the plots this difference was less than 10 ppm.

The nitrification rate of soil samples from first-year corn following meadow was markedly higher than from second-year corn plots. The nitrate production following clover was higher on first- than on second-year corn but the difference was not as large as found on the meadow plots. Corn following meadow was higher in yield than corn following clover. Nitrification rates paralleled the yield in the two treatments.

A composite sample of 10 cores, taken with a soil tube to a depth of six inches, was found to be representative of the soil conditions on the first- and second-year corn plots at Ames and Clarinda for all three sampling dates. The variability in

1 a. Chairman of Committee, W. V. Bartholomew, Dept. of Agronomy.
b. Doctoral Thesis No. 1252. Submitted March 12, 1952.

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These estimates may have been biased upwards by (1) differences in pre-test environment common to paternal half sibs, and (2) epistasis.

Some of the genetic correlations among the traits were:

test performance has not been practiced, since steady improvement has been achieved in Denmark, Sweden, and in certain small segments of the Canadian Yorkshire where test performance has been

	Length	Shoulder fat	Loin fat	Per cent ham	Loin area	Total score
Age.....	-.15	.13	-.01	.09	.10	-.13
Length.....		-.17	-.27	-.22	-.17	.46
Shoulder fat.....			.65	-.40	-.16	-.56
Loin fat.....				-.31	-.19	-.45
Per cent ham.....					.27	.24
Loin area.....						.48

The important genetic correlations were generally positive as regards merit so that genetic gain for each trait would be enhanced in a program of simultaneous selection. Only two were of such sign and magnitude as to retard progress. These were the correlations of length with loin area and with per cent ham, which were $-.17$ and $-.22$ respectively.

Despite the high heritabilities and the favorable genetic correlations, no material change in these traits has occurred in the Canadian Yorkshire during twenty years of performance testing. The most logical explanation is that consistent selection for

consistently utilized in selection.

Application of Advanced Registry test performance as a sib test could provide rapid genetic gain in all performance traits. If selection is based on a single carcass trait, carcass score appears to offer the greatest opportunity for improvement in over-all merit. Selection for rate of gain alone, which could be done on the basis of weight for age and would not require testing of the litter, will provide rapid improvement in both rate and economy of gain with slight improvement in the major carcass traits.

MICROBIOLOGICAL ASSAY PROCEDURES FOR VITAMIN B₁₂¹

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The vitamin B₁₂ content of some materials concerned with swine nutrition was determined by a microbiological assay, employing *Lactobacillus leichmannii* 313 (ATCC 7830) as the test organism. *L. leichmannii* 313 was preferred to *Lactobacillus leichmannii* (ATCC 4797) because it grew more rapidly, was quite sensitive to B₁₂, and gave a consistent response to a particular level of B₁₂.

The basal medium employed for *L. leichmannii* 313 was an improvement of a medium reported in the literature.³ This medium was essentially synthetic, including amino acids and vitamins, and supported good growth of the organism without further additions. However, a tomato juice filtrate was included to promote more rapid growth. The major improvement of the medium resulted from increasing the amounts of adenine, guanine, uracil, and xanthine from 1 to 3 mg. of each per

1 a. Chairman of Committee, L. A. Underkofler, Dept. of Chemistry.
b. Doctoral Thesis No. 1241. Submitted December 16, 1951.

2 a. B.S., Iowa State College, Ames, Iowa, 1948.
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3 Pee'ler, H. T., Yacowitz, H. and Norris, L. C. A microbiological assay for vitamin B₁₂ using *Lactobacillus leichmannii*. Proc. Soc. Exp. Biol. Med. 72:515-521. 1949.

100 ml. double strength medium. Cysteine, ascorbic acid, and thioglycolic acid could be used as the reducing agent in the medium, but cysteine appeared to be the most satisfactory.

Sterilization of assay tubes was accomplished by steaming for 5 minutes or by autoclaving 5 minutes at 15 pounds pressure. Samples and standard B_{12} were always sterilized with the medium; aseptic addition of B_{12} resulted in less growth. The sensitivity of the assay covered the range from 0.01 to 0.2 $\mu\text{g.}$ of B_{12} per tube (10 ml. medium per tube), with the most reliable range from 0.02 to 0.10 $\mu\text{g.}$ of B_{12} per tube.

Pyridoxal, pyridoxamine, and pyridoxine were utilized with equal facility by *L. leichmannii* 313 when the medium was sterile-filtered or steamed for 5 minutes. The organism could synthesize its vitamin B_6 requirement if incubated longer than the customary 18 to 24 hours for a B_{12} assay.

Desoxyribonucleic acid and its component nucleotides and nucleosides stimulated *L. leichmannii* 313, and caused difficulties in the assays of some materials. Satisfactory B_{12} assays were not accomplished with a chicken feed and swine rations. These materials were prepared for assay by extraction at pH 4.5 or by digestion with papain and takadiastase. Paper strip chromatography of feed samples showed two zones of activity in addition to the non-moving B_{12} zone. The fastest moving zone corresponded to thymidine.

Sow's milk was assayed after a papain and takadiastase digestion to coagulate the casein and liberate the B_{12} . These assays were complicated by the presence of nutrients other than B_{12} in the milk. The B_{12} content of the sow's milk was influenced to some extent by the B_{12} content of the feed, and ranged from 1 to 8 $\mu\text{g.}$ of B_{12} per liter. The purpose of the swine feeding experiment was to correlate the B_{12} content of the milk with the livability of the newborn pigs. No correlation was found, and the study of sow's milk was not extended.

Urine was assayed by diluting with water to the required volume, either with or without adjustment of the pH. A small amount of B_{12} was excreted in the urine of swine, varying from 0.5 to 3 $\mu\text{g.}$ per ml. Antibiotics present in the urine did not appreciably affect the assay.

The only tissue assayed for B_{12} in this investigation was liver, and this was the only material encountered that required any extensive preparation before assaying. The following method was employed for

liver: the sample was weighed and mixed with water, autoclaved at pH 7 with potassium cyanide, shaken for several hours in the dark at pH 5.5, and finally diluted to the required volume and filtered. No interference from desoxyribosides was noticed. The B_{12} content of livers ranged from 30 to 160 $\mu\text{g.}$ per gram.

The results of assays for one swine feeding experiment indicated that the pig excreted in the feces much more B_{12} than was consumed in the feed, suggesting intestinal synthesis of B_{12} . The fecal samples from this experiment were mixed with acetate buffer and autoclaved with cysteine prior to assaying. In this case, the assay tubes were sterilized by steaming for 5 minutes. Equivalent results were obtained in subsequent experiments by mixing the sample in acetate buffer and sterilizing the assay tubes by autoclaving to prevent the interference of fecal contamination.

For another swine experiment, assays were performed on the contents of the small intestine, cecum, large intestine, and feces in an effort to determine where the intestinal synthesis of B_{12} occurred. To be consistent, all the samples were mixed with acetate buffer and diluted with water to the required volume. Digestion with papain and takadiastase resulted in less activity; treatment with potassium cyanide increased the activity of the intestinal contents to some extent, but not of the feces. There was little B_{12} activity in the contents of the small intestine. The contents of the cecum, of the large intestine, and feces had comparatively large amounts of B_{12} , averaging about 300, 700, and 900 $\mu\text{g.}$ per gram, respectively. This indicated that the intestinal synthesis of B_{12} took place too far down the intestinal tract to be available for the pig.

The confirmation of B_{12} in the intestinal contents was ascertained by alkaline hydrolysis and paper chromatography. Alkaline hydrolysis of small intestine samples in 0.2 N potassium hydroxide resulted in 2 to 50 per cent loss of activity. Paper strip chromatography confirmed the presence of at least two substances that moved down the strip, in addition to the stationary B_{12} zone. Alkaline hydrolysis and paper strip chromatography gave no evidence of desoxyribosides in the samples of the cecum, large intestine, and feces.

The B_{12} activity of the intestinal contents was apparently bound in some manner to proteins. Filtration of the samples removed part of the activity; the more efficient the filter, the more activity it removed. Samples chromatographed on phosphate-buf-

ferred paper strips showed no movement, whereas B_{12} and B_{12b} moved from the original spot and gave a clean separation of the two vitamins.

The "bound B_{12} " was liberated by autoclaving or standing with potassium cyanide, and less efficiently by digestion with

papain and takadiastase. Two active substances were released by these treatments, moving on buffered paper strips approximately as B_{12} and B_{12b} . In the enzyme digested sample, most of the activity was in the B_{12b} zone.

FLORAL INDUCTION AND DEVELOPMENT IN ORCHARDGRASS¹

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Observations on the flowering responses of spring seeded orchardgrass and on flowering in a warm greenhouse have indicated that low temperatures are required for induction of flowers in this grass. These observations led to a study of the effect of photoperiod and temperature on floral induction of three orchardgrass strains in 1949 to 1952.

In the controlled induction experiments of 1949 and 1950, potted orchardgrass sods were held at three photoperiods, 18-hour, 9-hour, and normal fall day, and at three temperatures, 75°F., 65°F., and outside during the fall; and sods were then transferred to a warm greenhouse with an 18-hour photoperiod to permit development of the induced growing points. Plants maintained during this period at 65°F. or higher did not flower regardless of the photoperiod used. Sods subjected to 18-hour day-length remained vegetative indefinitely, regardless of the temperature used.

Data obtained from experiments in 1950, modified to include ten photoperiods ranging from 9 to 18 hours, agreed closely with those obtained in 1949. Flowering occurred only on plants maintained during the induction period under short days at low temperatures. Good flowering was obtained from plants held under photoperiods of 9 to 12 hours, including normal fall day, but lengthening the 12-hour day by as little as one-half hour reduced flowering by two-thirds, a highly significant differ-

ence. Flowering was sporadic with day-lengths longer than 12½ hours, even though the temperature during induction was low, and no flowering resulted from induction photoperiods of more than 14 hours. The responses of Kentucky bluegrass, used for a comparison, were similar to those of orchardgrass. Induction of Pawnee winter wheat was independent of photoperiods at the low temperature.

Sods transferred from the field to a long day in a warm greenhouse at 15-day intervals showed that induction of these orchardgrass strains occurred naturally by November 1 in both 1949 and 1950. Plants transferred before this date remained vegetative while those transferred on or after November 1 flowered, except for winter injured plants transferred in December 1950.

Floral induction under spring conditions was studied in 1950 and 1951. Lots of two strains of orchardgrass transferred in a vegetative condition to the field on April 8, 1950, flowered sparsely. The temperature was generally cool for a considerable period after this date, but the day-length was too long for successful induction. Potted plants flowered profusely when transferred on February 20 to a cold greenhouse and to the natural day-length. Flowering decreased significantly with transfers after this date until no panicles were obtained from plants transferred after April 1 when natural day-lengths were approaching 14 hours.

Spring seedings, in the field, of a large number of native and domestic grasses were variable in their flowering responses. Orchardgrass, reed canarygrass, red fescue, crested wheatgrass, and redtop did not flower in the year of seeding. Tall fescue, perennial ryegrass, and smooth bromeass flowered sparsely, while timothy and tall oatgrass produced a good

- 1 a. Chairmen of Committee, I. J. Johnson, Dept. of Agronomy, and W. E. Loomis, Dept. of Botany.
- b. Doctoral Thesis No. 1272. Submitted May 31, 1952.
- 2 a. B.S., Virginia Polytechnic Institute, Blacksburg, Virginia, 1949.
- M.S., Iowa State College, Ames, Iowa, 1950.
- b. Assistant, Agricultural Experiment Station.

quantity of flowers. Grasses of southern latitudes and some American native grasses, viz. big bluestem, side-out grama, weeping lovegrass, and switchgrass flowered abundantly in the seeding year, reflecting independence of a short day, cool temperature requirement for floral induction.

Cold chambers with thermostatically controlled temperatures and a cold greenhouse were used in the summer and fall of 1951 to study the interaction of photoperiod and temperature. Short photoperiods and low temperatures were applied separately and simultaneously during the induction period. Flowering occurred when all short photoperiods were given at a warm temperature, if the short photoperiods preceded the cool temperature, indicating that simultaneous application of the two factors is not necessary. Short days applied after the cool temperature were ineffective. Long photoperiods interposed between the short photoperiod and cool temperature exposures prevented induction.

Inducted plants subjected to varying photoperiods showed that long days were necessary for the initiation of inflorescences, i.e. the morphological transformation of the growing point into a floral primordium. Plants transferred to a warm temperature did not initiate flowers under short days, while plants under 13 hours or longer initiated well developed floral primordia. Initiation of inflorescences was more rapid under 24 hours than under 13

hours. Inducted plants, held florally inactive for 45 days by short photoperiods, flowered normally when transferred to long photoperiods.

After the completion of induction and initiation, plants subjected to three day-lengths and two fertility levels showed that long days and high nitrogen fertility favored the development of flowers and fruits. Only a few abnormal panicles developed on 9-hour plants, and the 20-hour photoperiod was superior to normal spring days in number of panicles produced and time required for flowering.

Orchardgrass and Kentucky bluegrass were responsive to management practices even though induction and initiation were successfully completed. Clipping Kentucky bluegrass during the induction period virtually prevented induction. Clipping orchardgrass for a short period during initiation and development reduced flowering, largely by removing the developing panicles. Severe freezing or a combination of freezing and transplanting following induction generally prevented flowering of orchardgrass. Injured plants produced tillers profusely, but these did not flower, indicating induction to be local rather than systemic. The localized effect of photoperiod was also borne out by an experiment in which divided plants were subjected to different photoperiods at a cool temperature. The induction stimulus received under favorable photoperiods by a part of the plant was not transferred to the uninducted part of the plant.

DISTRIBUTION AND NATURE OF PHOSPHORUS IN A GEO-CHRONO-SEQUENCE OF LOESS-DERIVED SOILS¹

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A study was made on the distribution and nature of phosphorus as functionally related to the morphological characteristics in a sequence of virgin-like Peorian loess-derived soils occurring on nearly level to level sites in southwestern Iowa

and northern Missouri. The soil profiles studied were, in the order of the degree of weathering, as follows: (1) Minden (P-217A), (2) Winterset (P-218A), (3) Haig (P-220), (4) Edina (P-16), and (5) Putnam (P-186). These soil series can be classified with the Prairie (Brunigra), Wiesenboden, and Planosol great soil groups.

The total phosphorus was determined in the profiles and was found to decrease in the profiles along the traverse in relation to the degree of soil weathering. The vertical distribution of the total phosphorus

- 1 a. Chairman of Committee, F. F. Riecken, Dept. of Agronomy.
b. Doctoral Thesis No. 1209. Submitted August 20, 1951.
- 2 a. B.S., Texas Agricultural and Mechanical College, College Station, Texas, 1939. M.S., *ibid.*, 1948.
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phorus was found to be affected by depth in the profiles. The lower A and B horizons tended to be low in total phosphorus in relation to the A and C horizons, but in no case was the A horizon in any profile higher in total phosphorus than the C horizon. The total phosphorus in the B horizons appeared to decrease in relation to time of soil weathering to a minimum in the intermediately weathered Haig profile and then to increase slightly in the highly weathered Planosols. The total phosphorus present in the profiles and the distribution of the phosphorus in the profiles strongly suggested that phosphorus had been lost from the profiles by leaching.

The organic phosphorus was found to amount to over 50 per cent of the total phosphorus in the surface samples in the profiles, and to decrease with depth to indeterminant amounts at some point in the B horizons. The rate of decrease in organic phosphorus with depth in the profiles appeared to be accelerated by the time of soil weathering. This effect was very pronounced in the bleached A₂ horizons of the Planosol soils (Edina and Putnam). The total phosphorus, organic carbon, and total nitrogen contents of the profiles were found to be related, but the organic phosphorus decreased directly along the traverse while the carbon and nitrogen first increased and then decreased in relation to distance along the traverse.

Solubility studies, with the soil-extractant suspensions varying in pH from around 2.0 to 11.0, gave some indication of the nature of the inorganic phosphorus

in the profiles. The results indicated that the inorganic phosphorus in the surface samples was rather indeterminant; that in the lower A and B horizons most of the inorganic phosphorus was associated with iron, aluminum, and clay; and that in the C horizons the major portion of the inorganic phosphorus was probably associated with bases such as magnesium and calcium. The trends along the traverse indicated that soil weathering had brought about a shift in the inorganic phosphorus forms from those associated with calcium and magnesium toward the iron, aluminum, and clay complexes.

A study of the release of phosphorus in relation to the release of iron, with and without a reducing agent in an acid extractant, indicated that some of the phosphorus in all horizons of all profiles was associated with iron. The changes in the iron-phosphorus relationships with depth in the profile strongly indicated that more phosphorus was associated with a given amount of iron in the A and C horizons than in the B horizons in all profiles except the Minden. These effects were explained on the bases of the soil weathering and the distribution of the free iron oxides in the profiles.

Theories were developed which might explain why some of the differences in the soil phosphorus occurred along the traverse. These theories were based on the assumption that time of soil weathering has been the major factor affecting the soil phosphorus as to content and distribution in the several profiles studied.

THE STRUCTURE OF NICKEL DIMETHYLGLYOXIME¹

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The structure of nickel dimethylglyoxime has been determined. The compound is orthorhombic with lattice constants, $a_0 = 16.68 \text{ \AA}$, $b_0 = 10.44 \text{ \AA}$, and $c_0 = 6.50 \text{ \AA}$. The space group for the structure is D_{2h}^{20} — Ibam.

The atomic positions were determined by three dimensional Fourier methods. The structure factors used in computing the electron density function were obtained from visually estimated intensities on Weissenberg and precession photographs. Back-shift corrections have been applied,

and the errors in the final parameters have been determined.

The nickel dimethylglyoxime molecule is planar. Although the molecular symmetry required by the space group is C_{2h} , the symmetry may be as high as D_{2h} . A layer structure exists in the crystal with a layer spacing of 3.25 \AA . An interlocking of molecules between layers and within the layers occurs in the crystal resulting in a tightly packed structure. The close packing is suggested as a possible explanation for the insolubility of nickel dimethylglyoxime.

The observed O — H — O distance of 2.44 \AA suggests the existence of an unusually strong hydrogen bond in the structure. An attempt is made to correlate the structure results with the infra-red absorption spectra of the compound.

Data are given for the construction of a Lorentz polarization factor chart for higher level precession photographs.

- 1 a. Chairman of Committee, R. E. Rundle, Dept. of Physical Chemistry.
b. Doctoral Thesis No. 1219. Submitted October 5, 1951.
- 2 a. B.S., Lehigh University, Bethlehem, Pa., 1943.
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ON QUADRATIC ESTIMATES OF VARIANCE COMPONENTS¹

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The problem considered in this thesis is the estimation of components of variance by quadratic functions of the observations. For example, consider the following linear model

$$y_{ij} = \mu + a_i + b_{ij} \quad \begin{array}{l} j = 1, 2, \dots, n \\ i = 1, 2, \dots, k \end{array}$$

where μ is an unknown constant and a_i , b_{ij} are independent random variables with means zero and variances σ_a^2 and σ_b^2 respectively. The problem considered is the estimation of σ_a^2 . We specify that the estimate Q_a must be a quadratic function of the observations and have the following properties:

1. Q_a be unbiased.
2. $\text{Var } Q_a$ be independent of μ .
3. $\text{Var } Q_a \leq \text{var } Q_a^*$ where Q_a^* is any other quadratic function of the observations which satisfy 1 and 2. Any quadratic estimator which satisfies these three conditions will be called a best quadratic unbiased estimator.

A method of estimating components of variance for linear models, is based on the analysis of variance. The estimate is obtained by equating observed mean squares to expected mean squares and solving the resulting equations. This is called the analysis of variance method of estimating variance components.

In this thesis certain theorems are stated as to when the analysis of variance method of estimation gives best quadratic unbiased estimates. If the method of the analysis of variance does not give the best quadratic unbiased estimates for certain models, then another method of estimation is given. The thesis is divided into three parts.

1 a. Chairman of Committee, Oscar Kempthorne, Dept. of Statistics.
b. Doctoral Thesis No. 1285. Submitted June 5, 1952.

2 a. B.S., William Penn College, Oskaloosa, Iowa, 1947.
M.S., Oklahoma A. & M. College, Stillwater, Okla., 1949.

In part one the following theorem is proved:

Theorem: Let $y_{i_1 i_2 \dots i_k}$ be given by the following linear model

$$y_{i_1 i_2 \dots i_k} = \mu + a_{i_1}^{(1)} + a_{i_1 i_2}^{(2)} + \dots + a_{i_1 i_2 \dots i_k}^{(k)}$$

$$i_t = 1, 2, \dots, n_t$$

where μ is a constant and the a 's are independent random variables such that

$$(a) E a_{i_1 i_2 \dots i_t}^{(t)} = 0$$

$$(b) \text{Variance } a_{i_1 i_2 \dots i_t}^{(t)} = \sigma_t^2$$

$$(c) E \left[a_{i_1 i_2 \dots i_t}^{(t)} \right]^4 = \mu_{4t} < \infty$$

Then the best quadratic unbiased estimate of σ_t^2 is given by the method of the analysis of variance.

In part two the following model was considered:

$$y_{ij} = \mu = a_i + b_{ij} \quad \begin{matrix} j=1, 2, \dots, n_i \\ i=1, 2, \dots, n \end{matrix}$$

where μ is a constant and a_i , b_{ij} are independent random variables with means zero, variances σ_a^2 and σ_b^2 respectively, and with fourth moments $3\sigma_a^4$ and $3\sigma_b^4$ respectively. The problem is to estimate σ_a^2 . In this situation the analysis of variance method does not yield the best quadratic unbiased estimate of σ_a^2 . The efficiency of the analysis of variance method is defined as

$$E = \frac{\text{variance of best quadratic unbiased estimate of } \sigma_a^2}{\text{variance of analysis of variance estimate of } \sigma_a^2}$$

Since the variance of the best quadratic unbiased estimate of σ_a^2 is a complicated function of σ_a^2 and σ_b^2 , a lower bound, E_L , on the

efficiency of the analysis of variance method is given by finding a lower bound on the numerator of E. This lower bound is a simple function of the ratio $W = \sigma_a^2 / \sigma_b^2$. It was found that in some situations the method of analysis of variance gives relatively inefficient estimates of σ_a^2 . Another estimate was introduced which gives better efficiency than the analysis of variance method when σ_a^2 times the minimum n_i is large relative to 2. A table is presented giving lower bounds on the two methods of estimating σ_a^2 for various values of W and various n_i .

In part three the following theorem was proved:

Theorem: Let $y_{i_1 i_2 \dots i_k}$ be given by the following linear model

$$y_{i_1 i_2 \dots i_k} = \mu + a_{i_1}^{(1)} + a_{i_2}^{(2)} + \dots + a_{i_k}^{(k)} + e_{i_1 i_2 \dots i_k}$$

where μ is a constant, the a 's and $e_{i_1 i_2 \dots i_k}$ are independent random variables. Also $e_{i_1 i_2 \dots i_k}$ is distributed normally with mean zero and variance σ^2 . $a_{i_p}^{(p)}$ is distributed normally with mean zero and variance σ_p^2 ($p=1, 2, \dots, k$). Let g and g_i ($i=1, 2, \dots, k$) be given constants. Then the best quadratic estimate of

$$\sum_{i=1}^k g_i \sigma_i^2 + g \sigma^2$$

is given by

$$\sum_{i=1}^k g_i \hat{\sigma}_i^2 + g \hat{\sigma}^2$$

where $\hat{\sigma}^2$ and $\hat{\sigma}_i^2$ ($i=1, 2, \dots, k$) are the estimates of σ^2 and σ_i^2 ($i=1, 2, \dots, k$) respectively which are given by the method of the analysis of variance.

FACTORS AFFECTING RANDOMNESS OF MATING IN ISOLATED POLYCROSS PLANTINGS OF MAIZE¹

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The standard procedure followed at present in breeding cross-pollinated crops involves the isolation of superior biotypes, their evaluation for combining ability, and finally their use in cross-combinations such as single-crosses, double-crosses or synthetic varieties.

The use of the polycross, or seed produced on selected clones interpollinated at random in isolation, has been suggested for the evaluation of combining ability in forage crops. Random mating is indispensable to have an equal pollen parentage in all clones compared and to measure differences in their inherent qualities.

The present study was undertaken to determine if random mating prevailed in the production of polycrossed progenies of maize, to study some factors that could condition departures from random mating and to evaluate the results in relation to the polycross as a test for general combining ability in forage crop breeding.

The problem was approached in two different ways: First, by comparing the yield performance of polycrosses of inbred lines of maize produced in different replicates of the same polycrossing block; second, by determining the pollination frequencies of nine stocks carrying recessive marker genes after allowed to open-pollinate in a replicated polycrossing block. In the last experiment, individual plant notes were taken on number of plants shedding pollen, length of pollen shedding period, plant height, date of tasseling and date of silking. Total weight of pollen shed by the stocks and the extent of differential fertilization that occurred among seven of the nine stocks were also determined. The effect of each one of these factors and position in the polycrossing block on the frequency with which a stock acted as a pollinator were examined by

means of regression and correlation analyses.

In one of two yield trials run, polycrosses of a line of corn produced in different replicates of the same polycrossing block differed significantly in their yield, presumably as a result of different pollen parentage. The range in yield among polycrosses of the same line in both tests was in general large and of sufficient magnitude to reach the level of significance in tests of higher precision.

The nine genetic stocks used in the pollination experiment varied in date of tasseling and silking, number of plants shedding pollen, weight of pollen shed, length of pollen shedding period and plant height.

An examination of the pollination frequencies in five stocks of similar flowering characteristics indicated that they deviated significantly from expectation under random mating when it was assumed that the number of gametes produced by them was the same. One of the stocks (*sh₁*) acted as a pollinator within reasonable limits of its expectation while two of them (*wxsu205*, *lg₂gl₂*) showed negative deviations and the remaining two (*bt₁*, *su*) positive deviations. The decreased functioning of pollen from stock *wxsu205* largely was attributed to a lower rate of establishment on the silks; in the case of *lg₂gl₂*, largely to the shorter period of pollen shedding resulting from the fact that anthesis started while the tassel was still enclosed by the leaves. The action of gameotophytic genes of the *Ga*, *Ga^s* and *sp* type was discounted as being responsible for the deviations from random mating observed in the pollination experiment.

Regression of per cent pollinations on number of plants shedding pollen, length of pollen shedding period and plant height was significant. The first two were positive and exceeded the 1 per cent level of significance while the latter was negative and significant at the 5 per cent level.

Although the regression of per cent pollinations on date of tasseling and silking was essentially zero over the whole experiment, intra-stock correlations of these characters indicated a marked tendency

1 a. Chairman of Committee, G. F. Sprague, Dept. of Agronomy.

b. Doctoral Thesis No. 1266. Submitted May 12, 1952.

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toward sibbing and more frequent pollinations among stocks of the same maturity group. The correlation coefficients were significant and negative in the early stocks, not different from zero in the intermediate group and significant and positive in the late stocks.

The association between the weight of pollen shed and per cent pollinations was insignificant, which was interpreted to indicate that, at least in this experiment, weight was a poor measure of the number of pollen grains produced by the stocks. No evidence was obtained pointing to more frequent crossing among stocks occurring in adjacent plots of the polycrossing block.

Results from paired pollinations with pollen mixtures to measure differential fertilization were conflicting; the trends observed did not explain the deviations from random mating in the pollination experiment.

A partial correlation analysis showed that the correlation between length of pollen shedding period and per cent pollinations was independent of number of plants shedding pollen and plant height. The correlation of the latter two characters with per cent pollinations was non-significant when length of pollen shedding period or plant height and number of plants shedding pollen or length of pollen shedding period, respectively, were held constant.

The test of significance for random

mating among the five stocks of similar flowering characteristics was based on the assumption that the number of gametes produced by them was the same. Without proof for this point and from a theoretical standpoint, this is not an absolute test. It is felt, however, that from a practical point of view it serves to call attention to the fact that it is not possible to expect random mating merely by planting material in the same field without paying any consideration to some of the factors that were found to affect the approach to random mating in this study.

It would not seem justifiable to try and control as many factors as possible to insure the closest possible approach to random mating. Such a procedure would make the obtention of polycrossed seed unnecessarily complex. It is suggested to produce artificially the intercrosses necessary to test general combining ability in forage crops to avoid the effect of factors that condition departures from random mating.

Although maize was used in this study, it is felt that the results obtained are applicable to other grasses. The varying degrees of cross-incompatibility and polyploid nature of forage grasses, as contrasted to the diploid behavior and cross-compatibility of corn would lead one to think that the situation in forage grasses might be even more complex than in corn.

STRUCTURE AND CHEMISTRY OF POLYIODIDE COMPOUNDS¹

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The structure of tetramethylammonium pentaioide, prepared by addition of iodine to tetramethylammonium iodide in an alcohol solution, was determined by X-ray diffraction. Crystals were found to have the symmetry of the monoclinic space group, C2/c. The lattice constants observed were

$$a_0 = 13.34 \text{ \AA.}$$

$$b_0 = 13.59$$

$$c_0 = 8.90.$$

$$\beta = 107^\circ 50'$$

The calculated density with four tetra-

methyammonium pentaioide molecules per unit cell was 3.06 g./cc. while the observed value was between 2.98 and 3.04 g./cc.

Patterson projections were made about the unit cell axes and also $a_0 + b_0$. A rough interpretation of the structure was obtained from these projections. Refinement projections were then made until all observed reflections were included. Back-shift corrections were applied to the parameters obtained from the final projection. The correlation factor, R, for the intensities calculated with these parameters was 0.20 for over three hundred observed reflections.

The iodine atoms lie in planes 4.3 Å.

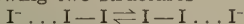
1 a. Chairman of Committee, R. E. Rundle, Dept. of Chemistry.

b. Doctoral Thesis No. 1258. Submitted March 14, 1952.

2 a. B.S., Iowa State College, Ames, Iowa, 1948.
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apart. Within these planes iodine-iodine distances are such that V-shaped groups, considered to be the pentaide anions, are separated by 3.55 Å. or larger. Within the pentaide anion the iodine-iodine distances are 3.14 and 2.93 Å.

The bonding in the reported triide anion was reexamined. Both the pentaide and the triide anions were interpreted to be bonded with a type of resonant bonding which uses only p-orbitals for bond formation. The resonant structure was pictorially represented for the triide anion by a resonance between the following two structures



and for the pentaide anion by a resonance among the following three structures



A molecular orbital treatment was employed to show that resonance stabilization is to be expected for both of these resonant structures. Some aspects of the chemistry of polyiodide compounds were explained by the proposed structure of these anions.

The structure of tetramethylammonium enneaiodide was investigated by single crystal X-ray diffraction technique. The crystals examined were found to possess the symmetry of the monoclinic space group $P2_1/n$. The lattice constants observed were

$$\begin{array}{ll} a_0 = 11.60 \text{ Å.} & \\ b_0 = 15.10 & \beta = 95^\circ 25' \\ c_0 = 13.18. & \end{array}$$

The calculated density with these lattice constants and four molecules of tetramethylammonium enneaiodide per unit cell was 3.51 g./cc. compared to the experimentally observed density of 3.47 g./cc.

Complete three-dimensional data were recorded with a Weissenberg camera; in addition, two-dimensional data around six axes were recorded with the precession camera. With these data two- and three-dimensional Patterson projections were made. They indicated that the iodine atoms form layers about 3 Å. apart. One two-dimensional electron density projection was obtained which gave a correlation factor, R , of 0.29 for intensity data calculated with parameters from this projection. Several possible structures were postulated.

INFLUENCE OF MOISTURE, AERATION, AND SUBSTRATE ON RATES OF BIOLOGICAL TRANSFORMATIONS OF CARBON AND NITROGEN IN SOIL¹

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Because of the importance ascribed to soil organic matter by agricultural advisors, intense interest has been created in developing practical methods for maintaining or increasing it in our agricultural soils. Green manures and crop residues have been used for this purpose. Previous work has indicated that the addition of plant residues to soil accelerates the rate of microbial activity and might result in

rapid mineralization of soil nitrogen and excessive loss of native soil carbon.

This study was undertaken to further elucidate these reactions. Samples of plant material labeled with isotopic carbon and nitrogen were incubated in the absence of soil and at various rates of addition in soil. Carbon losses and/or nitrogen changes were determined after various intervals of incubation. The use of the isotopes permitted a measurement of the quantity of carbon or nitrogen originating from the plant residues, the soil organic matter, or the fertilizer.

To obtain material labeled with C^{14} , plants were grown in an atmosphere containing radioactive carbon dioxide. The

1 a. Chairman of Committee, W. V. Bartholomew, Dept. of Agronomy.

b. Doctoral Thesis No. 1278. Submitted June 4, 1952.

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C^{14} studies were concerned with the rate of decomposition of plant materials and the effect of plant additions upon the loss of soil carbon. The net effect of these additions over extended time periods was measured.

Where corn stalk residues were added to the soil, greater loss of soil organic matter occurred than where no additions were made. Increasing the rate of residue addition increased the rate of soil carbon loss. Per gram of residue addition, acceleration of soil carbon loss was greater when small additions were made than when large amounts were applied. Loss of 100 mgm. of carbon from corn stalks added in 0.25 per cent amounts resulted in increased losses of 62 mgm. of soil carbon over the soil check; the same amount lost from the 5 per cent addition resulted in an increased loss of 8 mgm. of soil carbon during the 247 day period. Comparable values of accelerated loss for soybean residue were 15 mgm. for the low rate of addition and 4 mgm. for the high rate during a period of 119 days. Soybeans caused a greater initial loss of soil carbon than corn stalks.

Increasing the rate of residue addition decreased the relative rate at which the plant material decomposed. Decomposition of plant material was much faster in the presence of soil than in its absence.

The effect of plant additions on the acceleration of soil carbon loss was not of brief duration. While it was most evident in the early stages of decomposition, it was nevertheless still very evident after long periods of incubation. Addition of corn and/or soybean residue resulted in net gains of soil organic matter after extended incubation periods only where they were added at the rate of 5 per cent or 50 tons of dry matter per acre. Net losses occurred in all of the other samples and these net losses were of the same order of magnitude as those sustained where no residues were added.

The data obtained from the investigation of the effect of moisture tension on carbon loss showed that conditions which were

favorable for decomposition of plant materials were likewise favorable for the loss of soil organic matter. Plant materials which were easily decomposed accelerated soil carbon loss more than those which were slowly decomposed during the incubation period where comparisons were made. In causing accelerated loss, plant materials followed the order, soybeans > corn > Sudan grass \geq oats. Some differences among soils were demonstrated. Whereas organic matter loss was increased to a large extent in a Monona silt loam it was hardly affected in a Webster silty clay loam.

Partial pressure of oxygen influenced the rate of soil organic matter decomposition in about the same manner as it affected decomposition of plant material. Decomposition under a system of alternate wetting and drying was similar to that found where samples were kept continuously moist, both in respect to total decomposition and to soil carbon loss. In general any factor which stimulated the microbial activity in soil likewise accelerated the loss of soil carbon.

Nitrogen transformations were followed by using the stable isotope, N^{15} . Plant materials enriched in tracer nitrogen were added to soils and the changes in composition and quantity of the soil mineral nitrogen determined at several intervals of incubation. Additions of 1 per cent plant material caused greater mineralization of soil nitrogen than 0.5 per cent additions. This was true whether corn stalks or soybean straw served as the residue addition. Soybean straw caused greater mineralization of soil nitrogen than corn stalks.

Fertilizer nitrate nitrogen was rapidly immobilized in the soil in the presence of added plant material but no immobilization occurred in the absence of these additions. It appears that nitrate is not the form of nitrogen preferred by the microorganisms and that it is utilized only when the demand for nitrogen is high and the supply of other forms is inadequate.

PHYSIOLOGY OF *CHALARA QUERCINA* H. AND CHEMICALS FOR CONTROL OF OAK WILT¹

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Department of Botany and Plant Pathology

Oak wilt, caused by *Chalara quercina* H., is a threat to oaks in eastern United States. In forested areas the disease is controlled by eradication and sanitation. The success of these methods is dependent upon elimination of the infected trees. There are, however, thousands of oaks serving as shade trees which should be given individual treatment when they become infected.

The possibility of preventing or curing oak wilt in these trees through the introduction of chemicals into the vascular system was studied as a possible means to this end. Examination of thirty-five organic and inorganic chemicals revealed that several were effective in preventing and curing oak wilt in the greenhouse and the field. Up to 14 per cent of the two-year-old red oaks in certain treatments have been saved when chemicals were applied to the soil by means of an injection needle following inoculation. Up to 64 per cent survived when chemicals were applied prior to inoculation. Of the chemicals tested malachite green, sodium dimethyl dithiocarbamate + sodium 2-mercaptobenzothiazole, disodium ethylene bisdithiocarbamate, sodium 2-mercaptobenzothiazole, and 8-hydroxy quinoline sulfate were the most effective. These chemicals were noninjurious to the host at concentrations far in excess of those required to inhibit the fungus *in vitro*.

In greenhouse experiments cure of oak wilt was more successful in trees growing in sand than in trees growing in soil. This suggests interaction of chemotherapeutant

with soil constituents. Foliage applications of chemicals, alone and in conjunction with adjuvants, also resulted in some control of the disease.

Under field conditions *Chalara quercina* persisted for over nine months in logs of *Quercus ellipsoidalis* lying on the ground. The fungus was recovered from red oak twigs having a moisture content as low as 17 per cent, oven-dry basis. The incidence of recovery of the fungus, however, decreased with decreasing moisture content of the wood. Virtually no recovery of the pathogen occurred from wood having a moisture content of less than 20 per cent.

Basal sprays of 2,4-D and 2,4,5-T ester mixtures, applied to four species of oaks ranging from 3 to 18 inches d.b.h., produced 100 per cent kill during the period from broken bud to fully expanded leaf. Effectiveness of basal sprays decreased as the season progressed. Sodium arsenite and ammonium sulfamate severely injured but did not kill oaks when applied to holes in the bases of the trees in August.

Growth of *Chalara quercina* in agitated culture was not significantly different from that in quiet culture and no differences in toxin production could be detected. The toxic substance produced by the oak wilt fungus appeared in liquid media in approximately eight days and continued to increase through the twenty-fourth day. In partially buffered media maximum growth was obtained in culture adjusted to pH 4.2 and 5.1. Maximum toxin production occurred in media adjusted to pH 3.4 and 4.2. Optimum temperature for growth in liquid culture was 23° to 26°C.

Potato starch supported more growth than six other carbon sources but was inferior to d-fructose for toxin production. Asparagine was superior to ammonium nitrate as a nitrogen source for growth.

1 a. Chairman of Committee, W. H. Bragonier, Dept. of Botany and Plant Pathology.

b. Doctoral Thesis No. 1243. Submitted December 17, 1951.

2 a. B.S., Iowa State College, Ames, Iowa, 1948. M.S., *ibid.*, 1950.

b. Assistant, Agricultural Experiment Station.

Toxin production on the two sources, however, was equivalent.

Production or activity of the toxic material was inversely correlated with pH of the medium and was at a maximum below pH 4.0.

No distinction between nine *Chalara* isolates, obtained from three species of oak in two states over a period of four years, could be made on the basis of toxin production. No loss in pathogenicity, as determined by inoculation, occurred in the different isolates during the four years.

The toxic metabolic product of *Chalara quercina* was thermostable. It retained activity for one month at 6°C. Addition of ethanol to toxin containing filtrates produced a black precipitate. A water solu-

tion of this precipitate caused wilting of tomato cuttings but no necrosis or collapse of stems. The alcohol soluble fraction contained a component which produced leaf necrosis and stem collapse. The toxin was almost totally inactivated at pH 8.0 and to a lesser extent at pH 5.4. The reaction was reversible.

A timber cruise of Pilot Knob State Park revealed that oak wilt has destroyed 58 per cent of the merchantable oak in a stand of 271 acres. The loss was 538 thousand board feet. Approximately 10 per cent of this occurred in 1951. The Iowa survey for oak wilt revealed three new counties in 1950 and nine new counties in 1951. Indications were these did not represent new centers of infection.

SOME EFFECTS OF PLANT GROWTH REGULANTS¹

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This study on the auxin and anti-auxin activity of various chemicals was intended to increase our knowledge of the use of chemicals for controlling plant growth.

The auxin activity of 17 substituted indoleacetic acids was determined on tomato plants and split pea stems. In descending order the effectiveness was: (indoleacetic acid = IAA) 4-Cl:6-Cl-IAA = 4-Cl-IAA > 6-Cl-IAA > 5-Cl-IAA > 5-F-IAA > 5-Me-IAA > IAA > 2-Me-5-Cl-IAA = 7-Cl-IAA > 5,7-diCl-IAA > 2-COOH-5-Br-IAA. The following were inactive on the tomato test: 1-Me-IAA, 2-Me-IAA, 2-COOH-IAA, 2-Me-7-Cl-IAA, 2-COOH-5-Me-IAA, 2-COOH-7-Cl-IAA, and 2-Me-5,7-diCl-IAA. Substitution in positions 4, 5, or 6 led to activation of IAA. Substitutions in positions 1, 2, or 7 led to inactivation. The tomato test was a better test for differentiating activity than the split pea stem test.

Indoleacetic acid was compared with 4-Cl:6-Cl-IAA eutectic mixture and 2,4-D for phytotoxicity on twelve plant species. The 4-Cl:6-Cl-IAA was 10-100 times more effective than IAA and slightly less effective

than 2,4-D on most plant species. The range of selectivity of 4-Cl:6-Cl-IAA differed from that of 2,4-D. In a field trial, 4-Cl:6-Cl-IAA at a one pound per acre rate on corn completely prevented grain production and severely injured the plants.

The 4-Cl:6-Cl-IAA was considerably more effective than IAA for rooting of *Coleus* cuttings and preventing abscission layer formation in *Coleus* petioles.

None of the IAA's were effective in leaf modification.

Inhibition of the auxin effects of IAA, naphthaleneacetic acid, 2,4-dichlorophenoxyacetic acid, 2-benzothiazolyl-oxyacetic acid (2,4,6-T). The antagonism was reversed by higher concentrations of IAA, naphthaleneacetic acid, 2,4-dichlorophenoxyacetic acid and 2-benzothiazolyl-oxyacetic acid, indicating that the inhibition was competitive.

Inhibition of auxin effects by 2,4,6-T was demonstrated with the split pea stem technique, with tomato plant responses, and with *Coleus* rooting response.

Tomato plant responses controlled by native auxins that were inhibited by 2,4,6-T were negative geotropism of stems, transverse orientation of leaves to light, and rooting of cuttings. The growth of axillary buds was not stimulated by this anti-auxin, suggesting that the anti-auxin effect of 2,4,6-T differs from the anti-auxin effect of triiodobenzoic acid and maleic hydrazide.

1 a. Chairman of Committee, W. E. Loomis, Dept. of Botany and Plant Pathology.

b. Doctoral Thesis No. 1295. Submitted June 9, 1952.

2 a. B.S., University of Wisconsin, Madison, Wis., 1940.

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STABILIZATION OF THE LOCKED OSCILLATOR FREQUENCY DIVIDER WITH NONLINEAR ELEMENTS¹

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An important device in electronic applications is the frequency divider. Best known for its use in the television synchronizing generator, it is also used in radar applications and is indispensable in electronic computers. For that reason many different varieties have been designed.

Any electrical circuit that acts as a frequency divider must be nonlinear. The first frequency dividers were simply locked oscillators that depended upon the nonlinearity of the vacuum tubes that were used. Since the nonlinear characteristics varied with different tubes and with parameter changes such as plate and filament voltage, the original locked oscillators were quite unstable. This instability of the locked oscillator divider coupled with tremendous improvements in pulse techniques caused it to be superseded by pulse type frequency dividers.

It seems plausible, however, that if the

was possible to obtain an accurate mathematical expression for the volt-ampere characteristic of these elements. The form of that expression in every case was

$$E = KI^{1/n}$$

where n is a desired integer and K is the constant determined from the method of least squares.

It was possible to design oscillator circuits using these nonlinear elements that could be driven at several times their approximate natural frequency. The output frequency of an oscillator would, under certain conditions, adjust itself to be an integral submultiple of the driving frequency.

This subharmonic locking could, in some cases, be shown analytically. As a typical example, consider the following differential equation.

$$V = -K \left\{ \begin{aligned} &gmE_2 \cos 2\omega t + I_3 \\ &\frac{gmkC^3L^2Rp^5V}{C^3L^2Rp^5 + 4C^2L^2p^4 + 4C^2LRp^3 + 6CLp^2 + 2CRp + 2} \end{aligned} \right\}^{1/2}$$

dependence upon tube nonlinearity of the locked oscillator divider could be replaced by a dependence on an external nonlinear passive element, the stability of the divider might be improved. In that manner the random nonlinearity of the tube and its dependence on other parameter variations would be eliminated. The most practical external nonlinear elements available were General Electric Thyrite Resistors and Western Electric Varistors. Both of these products were nonlinear and perfectly bilateral conductors. In addition, by the use of a least squares curve fitting process, it

This is the equation that governs the action of the circuit designed to divide a given frequency by two. By means of substitution it can be shown that the above equation has an exact solution of the form

$$V = V_0 + V_1 \sin \omega t$$

provided that the following relations are true.

$$f = \frac{1}{2\pi\sqrt{LC}} \quad V_0 = 2V_1$$

This means that if the driving frequency is twice the above, the oscillator will lock with a two to one ratio.

It is reasonable to assume that if the above solution is exact for one frequency,

1 a. Chairman of Committee, George R. Town, Dept. of Electrical Engineering.

b. Doctoral Thesis No. 1246. Submitted February 18, 1952.

2 a. B.S., South Dakota School of Mines and Technology, Rapid City, S. D., 1949.
M.S., Iowa State College, Ames, Iowa, 1950.

solutions near that frequency can be represented by an assumed Fourier Series solution. It is obviously impractical to consider an infinite Fourier Series but a reasonable solution might be obtained by assuming a V of the form

$$V = V_0 + V_1 \sin \omega t + V_2 \cos \omega t + V_3 \sin 2\omega t + V_4 \cos 2\omega t$$

Considerable information is obtained from this procedure concerning driving voltage requirements and harmonic content of the output voltage.

The preceding procedure was followed in any analysis of a circuit designed to divide a given frequency by three although the assumed series solution led to unwieldy nonlinear algebraic equations. An exact solution for one frequency was obtained, however.

Additional circuits were designed to divide by the integers five and seven and they were successful although no exact analytical solutions were attempted for them.

All of the dividing circuits mentioned were considerably more stable than their pulse type counterparts. In the case of the circuits designed to divide by two and three, it was possible to vary plate voltage

and driving voltage more than 300 per cent. The driving frequency could be varied plus or minus 12 per cent. The circuits designed to divide by five and seven were almost as insensitive to driving voltage changes and frequency changes. They were sensitive to plate voltage changes but not as much so as the ordinary pulse divider.

Whether or not the locked oscillator divider is suitable for many applications remains to be seen. It certainly shows a great deal of promise.

USEFULNESS OF STUDENT CHARACTERISTICS FOR FORECASTING ACHIEVEMENT IN ORGANIC, PHYSICAL, AND ANALYTICAL CHEMISTRY¹

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There are several well-defined fields in chemistry. This study is limited to three of these fields, i.e., analytical, organic, and physical chemistry. At Iowa State College a sequence of three courses in each field is required for all majors in chemistry.

The purpose of this study was to provide the student, as well as the counselor, with available evidences of later achievement in these fields, and also the differential achievement among the fields.

During the six-year period ending in June, 1950, there were 285 students for whom complete information was available who graduated from the Iowa State College with credit for each of the three-course sequences. Considerable evidence was available to indicate that the students in this study were much more homogeneous than the general student body.

Six criteria of achievement were used in this study. Three of these were the average course marks in the three fields of chemistry. The other three were the differential achievement in one field as compared with another. The prediction, or independent, variables considered were eight in number, five of which were available as early as freshman week, and the other three were later achievement in college courses.

The first five variables available for early prediction of chemistry achievement were: (1) the Quantitative score on the American Council on Education Psychological Examination; (2) the Linguistic score on the American Council on Education Psychological Examination; (3) the high school grade-point average; (4) the score on the United States Armed Forces Institute Test on Correctness and Effectiveness of Expression, referred to in this study as the English Placement score; and (5) the score on the Reading Comprehension Section of the Iowa State College Silent Reading Test.

1 a. Chairman of Committee, James E. Wert, Dept. of Vocational Education.

b. Doctoral Thesis No. 1270. Submitted May 29, 1952.

2 a. B.S., Wilberforce University, Wilberforce, Ohio, 1936.
M.S., Iowa State College, Ames, Iowa, 1948.

Multiple regression analysis was used to determine the number of variables necessary to predict each of the criteria. For the average marks in the three-course sequence in analytical, organic, and physical chemistry it was found that prediction was not significantly more satisfactory from the use of all five variables than by using the ACE-Q score and the high school grade-point average. The degree to which these two variables would predict achievement is indicated by the coefficients of multiple correlation which were 0.3307, 0.4139, and 0.4591, in the respective fields. The relationships, although leaving much to be desired from the standpoint of student counseling, are similar to correlations reported in other studies where the group studied is homogeneous.

Later prediction of chemistry achievement may be made on the basis of class marks. The variables here used were: (1) sum of marks in a six-course sequence in mathematics; (2) all-college average, excluding achievement in mathematics and chemistry; and (3) sum of marks in a three-course freshman prerequisite sequence.

It was not unexpected to find the prediction more satisfactory from these col-

lege marks than from evidences available at the beginning of the freshman year. Multiple regression analysis, as well as the difficulty in assembling periodically the all-college average, suggested that the prediction of achievement be made from mathematics marks and freshman chemistry marks. The coefficients of multiple correlation with analytical, organic, and physical chemistry achievement were 0.5320, 0.4944, and 0.5712, respectively.

The differential achievement was found among fields with three criteria. The physical chemistry average mark was subtracted from the analytical chemistry average mark for A-P achievement criterion; the organic chemistry average mark was subtracted from the analytical chemistry average mark for the A-O criterion; and the organic chemistry average mark was subtracted from the physical chemistry average mark for the P-O criterion.

Correlations of these three criteria with freshman-week variables or later college achievement marks were so low, although in a few cases significantly different from zero, that efforts to counsel students on the basis of available test score evidence should be attempted with caution.

BACTERIAL UTILIZATION AND SEQUENCE DETERMINATION OF PEPTIDES¹

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Department of Chemistry

Preliminary experiments were performed for the purpose of selecting a chemical blocking agent for use with microbiological assays or paper chromatography in a subtractive method for determining terminal amino acid residues in peptides. Phenylisothiocyanate was found to be suitable for this purpose, and the method developed was tested on nine dipeptides and one tripeptide.

By use of selective hydrolysis of the

treated tripeptide by dioxane-HCl, the phenylisothiocyanate method could be employed for determination of amino acid residue sequence in the tripeptide.

Three peptides were assayed for utilization by *Lactobacillus arabinosus*. In the case of one of them, DL-valyl-DL-leucine, it was found that the L-leucine content was partly available, but that the L-valine content was not available at all.

The benzoyl derivatives of nine amino acids essential to *Lactobacillus arabinosus* 17-5 were tested for utilization by that microorganism, and only benzoyl-DL-leucine was found to replace the parent acid efficiently. Similarly, of ten benzoyl-amino acids, only benzoyl-DL-methionine could be shown to be available for *Streptococcus faecalis* R, and of twelve benzoyl-

- 1 a. Chairman of Committee, Sidney W. Fox, Dept. of Chemistry.
b. Doctoral Thesis No. 1218. Submitted October 3, 1951.
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b. Graduate Assistant, Agricultural Experiment Station, Industrial Science Research Institute.

amino acids only benzoylglycine was unequivocally available for *Lactobacillus brevis*. Dibenzoyl-L-cystine showed a questionable availability for *L. arabinosus* and *L. brevis*. When the benzoylamino acids were tested for inhibition against the three test microorganisms, slight inhibition of *L. arabinosus* by benzoyl-DL-tryptophan was noted. Only one strain of each species of microorganism was used, and the results may not apply to other strains.

Thirteen benzoylated dipeptides and one benzoylated tripeptide containing leucine, valine, or phenylalanine residues were tested for utilization by *L. arabinosus*. Two of these compounds, hippuryl-DL-leucine and benzoylalaninyl-DL-leucine, both having

a terminal leucine residue, were able to replace leucine. One of the remaining eleven compounds, none of which produced a growth response, was benzoyl-DL-leucyl-DL-leucine A, which also has a leucine residue at the carboxyl terminus.

During the course of these experiments the following compounds were prepared: benzoyl-DL-leucylglycyl-DL-phenylalanine (m.p. 185-187°), α -bromoisovaleryl-glycyl-DL-phenylalanine (m.p. 192° (dec.)), DL-valylglycyl-DL-phenylalanine (m.p. 231° (dec.) with softening at 226°), and benzoyl-DL-isoleucine (m.p. 138-139°). A compound recorded in the literature as benzoyl-DL-isoleucine was shown to be benzoyl-DL-alloisoleucine (m.p. 118-119°).

THE RESISTIVITY OF LANTHANUM, CERIUM, PRASEODYMIUM, AND NEODYMIUM AT LOW TEMPERATURES¹

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The electrical resistivity of lanthanum, cerium, praseodymium, and neodymium was measured between room temperature and approximately 2°K. The behavior was found to be affected by the method of preparation, the heat treatment, and the crystal structure of the samples, the latter bearing the greatest significance.

The decrease with temperature of the resistivity of all samples was nearly linear at room temperature in general agreement with theory. At very low temperatures the ideal resistivity, $[\rho]$, of lanthanum and praseodymium was found to obey the empirical equation $[\rho] = aT^b$, where T is the absolute temperature and a and b are constants. In no case was the value of b as high as Bloch's theoretical value of 5.

The face-centered cubic modification of lanthanum was found to possess a much lower resistivity (less than 70×10^{-6} ohm-cm.) at ordinary temperatures than the hexagonal close-packed form (approximately 100×10^{-6} ohm-cm.). It was hypothesized that the hexagonal form is

stable at room temperature and that the face-centered cubic structure undergoes a spontaneous transformation to the hexagonal form. The transformation may be inhibited in extruded specimens. An average superconducting transition temperature was found to be 5.8°K.

The transition in cerium from the normal face-centered cubic to the condensed face-centered cubic modification was found to begin at a temperature between 100 and 120°K. and to be accompanied by a large decrease in resistivity. Great thermal hysteresis was evident. The face-centered cubic crystals may transform into the hexagonal structure at a slow rate which depends upon the rate of cooling from the annealing temperature to room temperature.

An anomalous decrease in the resistivity of cerium which occurred at a temperature between 11 and 14°K. was attributed to a transition from the hexagonal close-packed to the condensed face-centered cubic structure, or, possibly, to a condensed hexagonal structure. No hysteresis appeared at these temperatures.

An anomalous decrease in the resistivity of neodymium appeared at approximately 12°K. The effect was possibly explained by a splitting of the lowest energy level of the ion by the field of its neighbors

1 a. Co-Chairmen of Committee, Sam Legvold, Dept. of Physics, and Frank H. Spedding, Dept. of Chemistry.

b. Doctoral Thesis No. 1248. Submitted March 3, 1952.

2 a. B.A., Carleton College, Northfield, Minn., 1947.

b. Assistant, Institute for Atomic Research.

and a consequent redistribution of the atoms among these states. The increase in the anomaly with successive thermal cycles may be the result of an annealing of the sample during the process of measuring the resistivity.

A comparison of the hexagonal close-packed modification of lanthanum with neodymium indicated that a decrease in resistivity was correlated with an increase in atomic number.

AN ECONOMETRIC ANALYSIS OF THE DEMAND FOR LIVESTOCK AND LIVESTOCK PRODUCTS¹

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With the existence of current farm legislation and the possibility that the Government will continue to formulate policy proposals to achieve certain desired results, the need arises for applying the best analytical tools to assist in attaining the desired goals. The ultimate purpose in the empirical study outlined here is to obtain quantitative approximations to some economic relationships. If reliable approximations can be obtained, then prediction may be possible.

The first stage in the analysis was the construction of an economic model which was assumed to "explain" sales, production and prices of livestock and livestock products, the amounts of feed fed and their prices. These economic magnitudes were considered to result from the interaction of a number of economic relationships.

Variables entering these relationships were classed as endogenous or exogenous. Endogenous variables were variables whose formation was to be explained. Exogenous variables were variables which were determined outside the system of relationships considered. The relationships in the economic model were not assumed exact relationships but were considered subject to disturbances or shocks due to non-included variables. To apply formal estimation procedures based on maximizing a likelihood function, a joint probability distribution was ascribed to these shocks.

The variables which were assumed to enter the various relationships will be written down, and below the model a brief description of the symbols will be given. Variables denoted by y are endogenous variables, those denoted by z are exogenous variables.

Relation

1. Livestock production relation.
2. Demand for feed grains.
3. Demand for protein feeds.
4. Supply of livestock products.
5. Commercial demand relation.
6. Supply of feed grains.
7. Supply of protein feeds.
8. Feed identity.
9. Farm livestock relation.

Variables entering relation

$$\begin{aligned}
 &y_{1t}, y_{8t}, z_{1t}, z_{2t}, u_{1t}. \\
 &y_{2t}, y_{5t}, y_{6t}, y_{7t}, z_{1t}, z_{3t}, z_{9t}, u_{2t}. \\
 &y_{3t}, y_{5t}, y_{6t}, y_{7t}, z_{1t}, z_{3t}, z_9, u_{3t}. \\
 &y_{1t}, y_{4t}, y_{5t}, y_{6t}, y_{7t}, z_{1t}, z_{3t}, u_{4t}. \\
 &y_{4t}, y_{5t}, z_{4t}, z_{5t}, z_{6t}, z_{7t}, u_{5t}. \\
 &y_{2t}, y_{6t}, z_{9t}, s_{1t}, u_{6t}. \\
 &y_{3t}, y_{7t}, z_{10t}, s_{2t}, u_{7t}. \\
 &y_{8t} = y_{2t} + y_{3t} + z_{3t}. \\
 &y_{9t} = z_{1t} + \lambda (y_{1t-1} - y_{4t-1}), u_{9t}.
 \end{aligned}$$

y_{1t} —livestock and livestock products produced in the United States in a given year. The sample in this study consisted of observations on the variables denoted by y and z for the years 1920-49 inclusive. However, observations for 1943 through 1946 were omitted because of price

1 a. Chairman of Committee, J. A. Nordin, Dept. of Economics and Sociology.
b. Doctoral Thesis No. 1294. Submitted June 9, 1952.
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control and rationing. The individual components of y_{1t} (cattle and calves, sheep and lambs, chickens, turkeys, broilers, eggs and milk) were combined into a single quantity index by weighting each component by its average farm price over the sample period.

y_{2t} — quantity of feed grains fed to livestock during the year. Quantity is measured in total digestible nutrients.

y_{3t} — quantity of protein concentrates fed to livestock. Quantity is measured in terms of total digestible nutrients.

y_{4t} — quantity of livestock products sold. Home consumed products were treated as sold. The individual components were the same as in y_{1t} and these components were weighted by average farm prices over the sample period.

y_{5t} — index of the price of livestock products sold during the year. The index was obtained by dividing estimated value of products sold by the quantity index y_{4t} .

y_{6t} — index of the price of feed grains obtained by dividing estimated value by the quantity index y_{2t} .

y_{7t} — index of the price of protein feeds obtained by dividing estimated value by the quantity index y_{3t} .

y_{8t} — total quantity of feed fed to livestock.

y_{9t} — index of the quantity of livestock held on farms at the end of the year. Numbers of animals in various classes

z_{10t} — domestic production of protein concentrates measured in total digestible nutrients.

s_{1t} — unobserved factors affecting the availability of feed grains for feeding in the current year. These include factors affecting foreign demand and supply and factors affecting government and private storage policies.

s_{2t} — unobserved factors affecting the availability of protein feeds for feeding in the current year. For the most part these are factors affecting foreign demand and supply. Explicit recognition was given to s_{1t} and s_{2t} in the economic model because of their obvious relevance but in the estimation process these two factors were, of course, ignored.

λ — a constant.

u_{1t} — $i = 1, 2, \dots, 7, 9$ is the disturbance.

The relationship whose parameters were estimated in this study was the commercial demand relation and this is the only relation whose algebraic form was specified. Two alternative forms for the demand relation were tried. In both cases the quantity variables (y_{4t} , z_{4t} , z_{5t}) were placed on a per capita basis by dividing them by z_{6t} . The relation was first assumed to be linear in these deflated quantity variables and the price variables and was alternatively assumed to be linear in the logarithms of the same variables. This gave the following relations to be estimated:

$$1.5 \beta_{54} y_{4t} + y_{5t} + \gamma_{54} \left[\frac{z_{4t}}{z_{6t}^*} \right] + \gamma_{55} \left[\frac{z_{5t}}{z_{6t}} \right] + \gamma_{57} z_{7t} + \gamma_{50} = u_{5t}$$

$$1.5' \beta_{54} \log \left[\frac{y_{4t}}{z_{6t}} \right] + \log y_{5t} + \gamma_{54} \log \left[\frac{z_{4t}}{z_{6t}^*} \right] + \gamma_{55} \log \left[\frac{z_{5t}}{z_{6t}} \right] + \gamma_{57} \log z_{7t} + \gamma_{50} = u_{5t}$$

were combined by estimating an average potential production for an individual animal in each category and using the estimates as weights.

z_{1t} — is y_{9t-1} .

z_{12} — time.

z_{3t} — roughage fed to livestock, measured in total digestible nutrients.

z_{4t} — is y_{4t-1} .

z_{5t} — consumer disposable income in the United States.

z_{6t} — population in the United States.

z_{7t} — Bureau of Labor Statistics' consumer price index.

z_{8t} — index of the price of farm labor.

z_{9t} — physical supply of feed grains measured in total digestible nutrients. Supply was taken to be carry over plus a fraction of the current crop.

where z_{6t}^* is population lagged one year.

Estimates of parameters in 1.5 and 1.5' were obtained by limited information and by least squares. In the least squares calculations y_{5t} was treated as the dependent variable and the others as independent. In the limited information calculations, the following were used as exogenous variables

$\frac{z_{1t}}{z_{10t}}, \frac{z_{3t}}{z_{10t}}, \frac{z_{9t}}{z_{10t}}$, or the per capita quantities of the

variables concerned. The results of these calculations are shown in Tables I and II. The calculated standard errors of the estimates are shown in Tables III and IV. The multiple correlation coefficients for the least squares calculations of 1.5 and 1.5' were respectively 0.986 and 0.988.

TABLE I
ESTIMATES OF PARAMETERS OF 1.5

Method	Parameter				
	β_{54}	γ_{54}	γ_{55}	γ_{57}	γ_{50}
Least Squares.....	.0181	-.0075	-.0012	-.0032	-.232
Limited Information.....	.0166	-.0069	-.0012	-.0034	-.175

TABLE II
ESTIMATES OF PARAMETERS OF 1.5'

Method	Parameter				
	β_{54}	γ_{54}	γ_{55}	γ_{57}	γ_{50}
Least Squares.....	1.484	.019	-1.118	-.449	1.541
Limited Information.....	2.163	-.258	-1.223	-.346	.926

TABLE III
STANDARD ERRORS OF ESTIMATES OF PARAMETERS OF 1.5

Method	Parameter				
	β_{54}	γ_{54}	γ_{55}	γ_{57}	γ_{50}
Least Squares.....	.0058	.0065	.00015	.0013	.376
Limited Information.....	.0059	.0065	.00015	.0013	.379

TABLE IV
STANDARD ERRORS OF ESTIMATES OF PARAMETERS OF 1.5'

Method	Parameter				
	β_{54}	γ_{54}	γ_{55}	γ_{57}	γ_{50}
Least Squares.....	.327	.354	.099	.157	2.80
Limited Information.....	.559	.426	.128	.185	3.62

TABLE V
ELASTICITIES FROM 1.5

Method	Price	Income	Variable General Price Level	Lagged Consumption
Least Squares.....	-.79	.76	.38	.41
Limited Information...	-.86	.83	.43	.42

TABLE VI
ELASTICITIES FROM 1.5'

Method	Price	Income	General Price Level	Lagged Consumption
Least Squares	-.674	.753	.303	-.013
Limited Information . . .	-.462	.565	.160	.119

The elasticities that economists commonly use to characterize demand relations were obtained from 1.5, the case of constant slopes, by placing y_{it} on the left and dividing through by the estimate of β_{it} . The elasticities in this equation were evaluated at the means of the relevant variables; the results are shown in Table V. The elasticities from 1.5', the case of constant elasticities were similarly obtained. The results are shown in Table VI.

Final and invariant statements on policy are not possible from the results of this study. Comparison with other time series and budget studies would seem to indicate that a function linear in the logarithms

of the observed variables yielded more plausible results than a function linear in the observed variables. The numerical estimates of parameters of 1.5 obtained by least squares differed but little from those obtained using limited information. However, some difference was observed between the results from the two estimation methods employed on 1.5'. If, in fact, the multiple equation description of the livestock market is more appropriate than a single equation description then limited information is to be preferred as an estimation procedure to that of single equation least squares.

TECHNIQUES FOR ANALYZING FARM FAMILY LEVEL OF LIVING AND RELATED FACTORS IN IOWA¹

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The purpose of this study was to develop and/or to apply several alternative methods and techniques which would increase understanding of areal differences in farm family levels of living in Iowa and of the relationship of those levels to selected social and economic variables.

Nearly all previous level of living studies have been concerned with scalar stratification of families according to some single or multiple criterion. The increasing amount of pertinent census data has made possible the construction of farm family level of living indexes for such units as the county and the township. Differences in levels of living, as represented by the indexes, can be delineated, and analysis made within areas of the relationships of such indexes to

selected variables associated with farm family levels of living.

Methods followed in this study were: (1) identification and description of variations in Iowa of farm family levels of living and through correlation and regression analysis the relationship of selected variables to level of living; (2) testing type of farming areas for usefulness in level of living area delineations; (3) determination of variations in levels of living within and between principal soil association areas and of the relationship of selected variables to level of living within each; (4) delineation of homogeneous level of living areas and determination of the relationship of selected variables to level of living within the combined homogeneous areas and the non-homogeneous portion of the state; and (5) determination of the ecology of level of living and of related variables and identification of areas in which there is general correspondence in the rank of level of living in relation to each of the variables.

1 a. Chairman of Committee, Ray E. Wakeley, Dept. of Economics and Sociology.
b. Doctoral Thesis No. 1296. Submitted June 9, 1952.

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The twelve variables chosen for analysis of relationship to farm family level of living were: size of farm; per cent tenancy; crop productivity; per cent 1940 population is of the 1900 population; per cent rural farm population; value of implements and machinery; value of land and buildings; township participation rating score; corn yield; number of persons per 100 acres; mechanization index; and per cent foreign born or of foreign or mixed parentage.

After preliminary analysis of the usefulness of the variables on a state basis, the first seven were retained for subsequent analysis of relationship to level of living on the state and the various area bases.

Townships in Iowa differed widely in the average level of living attained by their farm families, ranging from a low index of 60 to a high of 228. The mean was 164. The implications of the variations are many, not only for the families, but for all social and economic aspects of the whole agricultural plant.

The higher level of living areas generally were located in a broad belt extending from southeast to northwest Iowa. The average level of living was highest in the North Central Grain type of farming area, followed by East Central Meat, Western Meat, Northeast Dairy and Southern Pasture.

Level of living indexes by principal soil association areas ranged from 134 to 183 with the higher indexes and the greatest homogeneity generally occurring in the highly productive and level soil areas. In 24 of the possible 28 two-area combinations of soil areas, highly significant differences in levels of living were found. Crop productivity correlated most highly with level of living in six areas, while value of land and buildings did so in two areas. Other variables showed widely varying degrees of association with level of living from area to area.

Eighteen homogeneous areas using level of living as the internal attribute and containing from 18 to 74 townships each for a total of 759 townships were delineated. Maximum range in indexes in each of the areas was limited to the equivalent of one standard deviation for the state or 27 index points. In general, homogeneity was found to proceed in a broad belt from northeast to southwest Iowa and to include most of the level topography.

Multiple correlation analysis in which the seven variables in combination were correlated with level of living resulted in

the following coefficients (R): state, .8148; soil association areas, .6031 to .8098; the combined homogeneous areas .8717; and the non-homogeneous area .8317.

The final phase of this study was that of showing township by township where in Iowa there is a general correspondence in the rank of level of living in relation to each of the seven variables. By means of tables and maps it was possible to: (1) show townships in which there is a correspondence between the rank in level of living and each of the variables; and (2) show townships in which the level of living ranked above or below the variables.

Contributions of the study were: (1) demonstration of the usefulness of the farm family level of living indexes by townships to indicate the existent wide variations in and uniform concentrations of levels of living; (2) adaptation of township indexes to analysis by soil association or any other areas with irregular contours; (3) identification and delineation of small homogeneous level of living areas by use of indexes; (4) usefulness of the indexes in mapping township by township the relationship of rank of level of living and that of each of the variables; (5) determination of the lack of consistency from area to area in the associational relationship of the variables to level of living; and (6) determination of the differences in ability of variables to predict level of living from area to area.

Other investigations might well include: (1) further validation of the relationship of soil associations, and particularly soil types, to levels of living; (2) further validation of the homogeneous level of living areas and an analysis of their unique characteristics with some experimentation to determine their usefulness as areas for other types of social and economic research; (3) attempts to delineate areas which are homogeneous with respect to large complexes of internal attributes including level of living; (4) studies of level of living time series data by areas and the relationship of change in levels of living to that of related variables; (5) determination of causes of differing changes over time in level of living when initial level of living indexes are the same; (6) identification of individual and groups of townships in which a uniform set of variables predicts level of living with a high degree of reliability; and (7) experimental testing in different level of living areas of the effects of an educational program for increasing level of living.

MECHANISM OF MOISTURE MOVEMENT IN THE DRYING OF ORGANIC GRANULAR SOLIDS¹

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An equation was derived for the drying of soybeans, assuming that the beans are spherical and homogeneous. The mechanism of moisture movement was assumed to be diffusion. As a result, the diffusion equation has the form:

$$\frac{C_a}{C_0} = \frac{6}{n^2\pi^2} \sum_{n=1}^{\infty} (\exp) - (n\pi/R)^2 Dt$$

where C_a is the average moisture concentration at any time t , and C_0 the initial moisture concentration when $t = 0$. R is the radius of the soybean, and D the diffusivity of the material.

The radius of the bean is expressed in centimeters, time is expressed in hours, and the moisture concentrations are dimensionless according to the definition:

$$C = \frac{\text{Mass H}_2\text{O}}{\text{Mass Dry Solid}}$$

Diffusivity, D , then has the dimensions of square centimeters per hour.

According to this equation, in a given environment, the drying is accomplished in two falling rate periods. During the first period the diffusivity remains constant, and during the second period it gradually decreases with lower moisture concentrations. The termination point of the first falling rate period was found to be at an average moisture concentration of 0.16. It is reasonable to postulate the theory that in the moisture concentration range below 0.16 the biochemical cellular structure of the soybean is changed, so

that it becomes less permeable to moisture movement.

Diffusivity was related to the drying conditions by dimensional analysis. The drying characteristic of the soybean was evolved to be of the form:

$$C_a = f \left[\frac{Dt}{R^2}, \frac{Vt}{R}, \frac{P_{sm} - P_w}{P} \right]$$

where V is the air velocity in centimeters per hour, P is the barometric pressure, P_w the partial pressure of water in the air, and P_{sm} the mean vapor pressure of water at the bean surface temperature. Any consistent set of units may be used for these pressures.

Experimental drying tests showed that the air velocity, V , had no effect on the drying rate in the range studied (23 to 52 fpm). Therefore, the (Vt/R) group was eliminated. Diffusivity was related to the $(P_{sm} - P_w/P)$ term in the two falling rate periods as:

$$C_a = 0.35 \text{ to } C_a = 0.16$$

$$D = \frac{P_{sm} - P_w + (0.01)P}{(69)(P)}$$

$$C_a = 0.16 > 0$$

$$D = \frac{\log \left[\frac{C_a}{C_0 (0.0088P/P_{sm} - P_w)^{1.63}} \right]}{770}$$

The $(P_{sm} - P_w/P)$ group may be viewed as the driving force or drying potential, since it is an index of the vapor pressure difference of water in the air and on the drying surface. As this vapor pressure difference is increased the rate of drying increases.

Experimental drying tests were also conducted with shelled corn. The drying characteristic of corn does not exactly parallel that of soybeans. Initially, corn

- 1 a. Chairman of Committee, Glenn Murphy, Dept. of Theoretical and Applied Mechanics.
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drys at a faster rate than soybeans, and finally has a slower rate.

Drying information for corn may be predicted from soybean experiments at the same drying conditions. The two sets of data were related by an F factor defined as:

$$F = \frac{(\pi^2 Dt / R_e^2) \text{ corn}}{(\pi^2 Dt / R^2) \text{ soybeans}}$$

where the R_e is called the equivalent radius of the corn kernel. R_e is calculated as the radius of a sphere having the same surface area as the surface area of the actual corn

kernels. The F factor for the corn was found experimentally to be:

$$C_n = 0.30 \text{ to } C_n = 0.16$$

$$F = 1.1$$

$$C_n = 0.16 > 0$$

$$F = \frac{0.12}{(\pi^2 Dt / R^2) \text{ soybeans}} + 0.67$$

The correlation of data in this study appears to be sufficient to justify the assumptions made in the drying mechanisms developed.

AN ECONOMETRIC ANALYSIS OF THE DEMAND FOR EGGS¹

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The primary objective of quantitative research in the field of agricultural economics is to measure the network of economic relationships that explain the functioning and results of the mutual interdependence between the sectors of our economy. The purpose of studying such interrelations is to obtain an explanation of the mechanism that determines the level of economic activity and, thereby, the general economic welfare of our economy.

Since the time economists and statisticians began their attempts to measure supply and demand curves and empirically verify other laws of economic behavior from statistical data, the problem of the best method of estimation has been the subject of investigation and discussion. The classical least-squares method, in the earlier years, was the main vehicle by which estimates were obtained in the field of quantitative research in agricultural economics. Rather widespread dissatisfaction was felt with this procedure as an analytical tool.

In the last few years, new approaches to the problem of verifying economic laws have been introduced. From both an eco-

nomic and a statistical viewpoint, these new methods of estimation are superior to the older methods in many ways.

The principle of fit on which these new methods are based gives statistical expression to an assumption which is at the very basis of economic theory, including the theory of economic fluctuations: the assumption that the formation of economic variables can only be described by a system of simultaneous equations. These methods involve many observations of man's economic behavior that are outside the particular segment of the economy to be studied and, therefore, have an indirect rather than a direct effect upon the sector under study. Methods such as these are necessary if we follow the theory of Walras and view the economy as one complete model with the divisions between sectors and commodities as only arbitrary. This investigation is an attempt to apply the new methods of statistical estimation to the models that were constructed from economic theory.

Where statistical data are used as one of the foundation stones on which the equation system is erected, the modern methods of statistical inference are an indispensable instrument. However, without economic theory as another foundation stone, it is impossible to make such statistical inference apply directly to the equations of economic behavior which are most relevant to analysis and policy discus-

- 1 a. Chairman of Committee, J. A. Nordin, Dept. of Economics and Sociology.
- b. Doctoral Thesis No. 1281. Submitted June 5, 1952.
- 2 a. B.S., University of Kentucky, Lexington, Ky., 1948.
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- b. Associate, Agricultural Experiment Station.

sions. Statistical inference unsupported by economic theory applies only to whatever statistical regularities and stable relationships can be discerned in the data. The more detailed the specifications of our theory, as to the form of the structural relationship, the variables which enter into each equation and any other further details supported by prior observation or deduction, the greater the scope we will be able to give to statistical inference from the data to the structural equations.

The main objective of this study was to evaluate those factors which appear to have the most influence on the fluctuations in the demand and supply of eggs. In order to derive, empirically, the effect of each of these factors and to study the mutual interdependence between the parts of our economy, it was necessary to establish the complete determinate system of relations that tied the many economic variables together.

In this study, a self-imposed limitation was that we consider the problem of the estimation of the parameters of demand and supply, not the problem of the prediction of the values of economic variables such as production, consumption, prices, etc. In these cases, we were dealing with a type of prediction in which one or more of the relations found to govern the past are altered and which is, therefore, not a straight forecast assuming continuation of the past relationships.

In order to obtain quantitative estimates of the effect of these many factors on the consumption and the production of eggs, several econometric models were constructed which could be tested statistically. The models constructed varied from a large twelve-equation model to a single-equation model that formed a complete system. The different models constructed required the use of three different methods of estimation. The three methods of estimation were as follows:

1. The limited-information method, which was used when the equation to be estimated from the system of equations was over-identified.
2. The reduced-form method, which was used when the equation to be estimated from the system of equations was just-identified.
3. The classical least-squares method, which utilized only the information contained in a single equation.

Each of the models and methods was then confronted with data from two sample periods. One sample period consisted of annual data for the years 1921-41, and the

other sample period considered annual data for the years 1921-50.

The results from the different models, methods and sample periods present a somewhat diverse picture, and any attempt to use them to decide the best method of estimation is futile. Examination of the extent to which the signs and magnitudes (or relative magnitudes) of the various coefficients conform with whatever *a priori* expectations we had about them is about as much as the economist, as such, can do to decide whether the models do or do not produce sensible results. Unfortunately, the true parameters for the equations are not known, and thus it is impossible to say which of the estimates more closely approximates the true parameters.

Only the results for one demand and one supply equation using the limited-information method will be given. The demand equation using 1921-41 data may be summarized as follows:

1. A one per cent increase in the price of eggs would result in approximately a 0.58 per cent decrease in the quantity of eggs consumed, *ceteris paribus*.
2. A one per cent increase in the price of meat would result in approximately a 0.60 per cent increase in the quantity of eggs consumed, *ceteris paribus*.
3. A one per cent increase in the price of other food would result in approximately a 0.49 per cent decrease in the quantity of eggs consumed, *ceteris paribus*.
4. A one per cent increase in the per capita disposable income would result in approximately a 0.44 per cent increase in the quantity of eggs consumed, *ceteris paribus*.
5. A one per cent increase in the lagged disposable income would result in approximately a 0.29 per cent increase in the quantity of eggs consumed, *ceteris paribus*.

The supply equation using 1921-50 data may also be summarized as follows:

1. A one per cent increase in the price of eggs received by farmers would result in approximately a 1.13 per cent increase in the quantity of eggs produced, *ceteris paribus*.
2. A one per cent increase in the price received by producers for livestock would result in approximately a 0.44 per cent increase in the quantity of eggs produced, *ceteris paribus*.
3. An increase of one per cent in the lagged price of eggs received by farmers is

associated with a 0.30 per cent increase in the quantity of eggs produced, *ceteris paribus*.

4. An increase of one per cent in the cost of the poultry ration is associated with an 0.88 per cent decrease in the quantity of eggs produced, *ceteris paribus*.
5. An increase of one per cent in the lagged cost of the poultry ration is associated with 0.77 per cent decrease in the quantity of eggs produced, *ceteris paribus*.

The results obtained in this investigation could be used to judge in advance the effects of the various policies that might be considered. Some knowledge of the mutual interdependence of these and of other relations in the various parts of the economy is, obviously, a prerequisite for intelligent formulation of government policies such as price regulations and ration-

ing, forward prices, price support devices such as commodity loans and price discrimination, public spending, etc. If the policy we are considering represents a change in the structure, and if the structure before the change is known, then the structure after the change is also known, and we can compare the two. There are a variety of practical policies that are precisely of this type.

The reliability of the results and conclusions given, of course, depends upon the assumptions on which the models are based, the data and the methods of estimation that were employed. Much careful research is yet to be carried out to check these tentative conclusions. The advent of more and better data and a clarification of the newer methods of estimation should do much to give us more reliable results.

RELATIONSHIP OF FOWL LYMPHOMATOSIS TO ROUS SARCOMA¹

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Fowl lymphomatosis is a neoplastic disease of major economic importance to the poultry industry, which is usually considered to include the ocular, neural, visceral and osteopetrotic forms. The long and variable incubation period, as well as the difficulty in obtaining disease-free susceptible stock, interfere with progress in recognizing the carrier-hen. Such hens may transmit lymphomatosis through the egg to the chick. Consequently, a satisfactory test, capable of identifying infected individuals, would aid in the control of this disease.

The high incidence of Rous neutralizing antibodies (RNA), in the sera of birds from flocks experiencing significant losses due to the lymphomatosis-complex, may suggest an antigenic relationship between fowl lymphomatosis and the Rous sarcoma. Should this relationship exist, the Rous virus neutralization test might then be used in detecting lymphomatosis-carrier

hens, thus aiding in reducing the incidence of this disease.

The objective of the present study was directed toward the clarification of the antigenic relationship, based on the occurrence of RNA, the tissue pathology and the flock history. The incidence of RNA was also determined in cases of experimental lymphomatosis produced through inoculation of a cellular suspension obtained from an avian myxosarcoma.

The presence of RNA and the number of neutralizing doses per ml. of serum were determined through the use of the neutralization test. The quantity of Rous virus was evaluated through determination of the minimal infective dose based on the 50 per cent lethal endpoint. Serum-virus mixtures were inoculated subcutaneously into two-week-old chicks. Quantitative evaluation of Rous tumors, ranging from 4.0 to 0.0 were utilized in the determination of a tumor index. Tumor indices of 0.0-2.0 were considered as evidence of neutralization.

The following types of avian populations were studied: (1) flocks with a 20 to 50 per cent incidence of lymphomatosis; (2) flocks with less than 5 per cent incidence of lymphomatosis; (3) two flocks hatched together, one from stock with a 41 per cent incidence of lymphomatosis,

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- 2 a. B.S., South Dakota State College, Brookings, S.D., 1934.
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and the other from stock with less than a 4 per cent incidence of this disease; and (4) birds inoculated with tumor suspensions.

The observations made during this study include:

1. Over 60 per cent of the sera from field flocks with 30 to 50 per cent losses due to fowl lymphomatosis contain Rous neutralizing antibodies (RNA).

2. Where losses due to fowl lymphomatosis are less than 5 per cent the incidence of RNA is less than 10 per cent, while no antibodies have been demonstrated in sera from some of these populations.

3. Rous neutralizing antibodies are present in over 40 per cent of the sera of the birds hatched from a population which experienced a 41 per cent loss due to fowl lymphomatosis in two years.

4. Cases of fowl lymphomatosis (lymphocytomas?) were observed in a population where no RNA were demonstrated.

5. The incidence of RNA appears greatest in birds with the visceral type of lymphomatosis. These antibodies have also been observed in sera from cases of ocular and neural lymphomatosis, but not from cases of the osteopetrotic type.

6. A cell-containing suspension of a myxosarcoma has been shown to produce visceral lymphomatosis in three serial sub-inoculations. Rous neutralizing antibodies were consistently present in the first inoculation series and occasionally in the second and third series.

7. A method, based largely on the technique of Duran-Reynals, for de-

termining the presence and evaluating the quantity of RNA is outlined.

8. The transmission of the agent causing visceral lymphomatosis through contact is substantiated.

9. The transmission of an agent through contact, capable of stimulating RNA, is shown.

10. The transmission of an agent through the egg, capable of stimulating RNA, is shown.

11. Some of the experimental evidence obtained in this study supports the concept of non-transmissible lymphoid tumors.

The high incidence of RNA in flocks, where severe losses due to lymphomatosis have occurred, may suggest an antigenic relationship to the Rous sarcoma. Many of the connective tissue tumor agents appear to be antigenically related; however no report of such a relationship to a lymphoid tumor agent has been shown. Some of the other tentative explanations should include: (1) concurrent infections of the lymphoid tumor agent group and the connective tissue tumor agent group, obtained through the egg, from infected eggs at the time of hatching or through contact with infected older birds; (2) a synergistic relationship between lymphoid tumor agents and connective tissue agents, which is expressed by a high incidence of visceral lymphomatosis; and (3) the neoplastic potentiality of the connective tissue tumor agent group to attack lymphoblastic cells or precursors of the lymphocytic series.

THE APPLICATION OF THE HAMMETT EQUATION TO THE SOLVOLYSIS OF BENZYL TOSYLATES¹

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The solvolyses of benzyl *p*-toluenesulfonate and its derivatives, *m*- and *p*-styryl, *m*- and *p*-phenylacetylenyl, and *p*-nitrobenzyl tosylates, have been studied in 55.6 per cent acetone-water solutions at 25.25°C.

1 a. Chairman of Committee, George S. Hammond, Dept. of Chemistry.

b. Doctoral Thesis No. 1292. Submitted June 7, 1952.

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under conditions of constant ionic strength. The rates of solvolysis of these tosylates are correlated with the corresponding *sigma* values of Hammett.³

The fairly large negative value, -2.19, obtained for *rho* is discussed in terms of the transition state for the solvolysis. The extreme reactivities of *p*-methoxy, *p*-

3 L. P. Hammett, "Physical Organic Chemistry," McGraw-Hill Book Co., New York, N.Y., 1940, p. 188.

methyl and *p*- β -styrylbenzyl tosylates may be attributed to the stabilization of the transition state by the facile interaction of the non-bonding electrons of the *p*-methoxy, *p*-methyl or *p*- β -styryl group with the benzene ring. A comparison of the rates of reaction of benzyl tosylate and benzyl chloride under similar conditions is made.

The difference in the *sigma* values of the β -styryl group and the phenylacetylenyl group is rationalized on the basis of the greater localization of the π electrons in ethylenes with respect to acetylenes. This generalization is in conformity with the observed rates of solvolysis of *p*- β -styryl and *p*-phenylacetylenylbenzyl tosylates.

The rates of solvolysis are found to be dependent upon the dielectric constant of the solvent in the predicted manner for an S_N1 type reaction. There appears to be, however, an unusual insensitivity of the rates to ionic strength. A twenty-fold increase in ionic strength is found to increase the rate by only ten per cent. An interesting effect has been found to be operative when the solvolyses are carried out in salt solutions of potassium chloride or potassium nitrate in which the reaction does not go to completion. The kinetics can be accounted for by assuming a competitive reaction between water and chloride or nitrate ion for benzyl carbonium ion.

INHERITANCE AND INTERRELATIONSHIPS OF SOME MAIZE EAR CHARACTERS¹

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The interrelationships of the maize ear characters: cob weight, cob length, cob diameter, kernel weight, silking data, pH of a water extract of cob meal, cob breaking strength, midcob color, and resistance to *Nigrospora oryzae* infection were studied in a number of inbred, single cross, and backcross combinations. Environmental effects on some of these characters were examined in a group of 54 single crosses grown in six different districts in Iowa in 1949.

The various characters were not all studied together in any one year but were examined in different character combinations in the years 1930 through 1933 and 1949 through 1951. A wide range of genetic backgrounds was encompassed in this study. Supplemental observations were made on midcob color and breaking strength from 1933 through 1943 in commercial breeding of sugary maize.

Maize inbreds were mostly from the Corn Belt dent types but some studies and observations included flint, sugary, and pop types. Genotypic backgrounds were chiefly inbred or F_1 but some continuation

generations were studied as F_2 or backcrossed progenies. All studies were done on an individual plant basis.

Statistical techniques employed included correlation, partial regression, multiple correlation, and variance component analyses. These methods assisted in establishing confidence in the interrelationships and interactions hypothesized during the research.

The inverse relationship, found by Reddy, of pH of mature cob meal extract and *Nigrospora* resistance with the susceptibility threshold at pH 5.0 to 5.2 was confirmed. Both characteristics have a relatively simple genetic control highly conditioned by environmental variations. Intensity of midcob color and breaking strength exhibited a similar inverse relationship with pH and had a genetic background as highly responsive to environmental variation as cob pH and *Nigrospora* resistance.

The traits of pH reading, breaking strength, midcob color, cob weight, and *Nigrospora* resistance develop simultaneously with kernel weight. Correlation and partial regression coefficients computed for three differing groups of single crosses showed the interrelationships of these characters with yield. The predictive value of cob weight, cob length, and cob diameter combined for estimating single

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b. Doctoral Thesis No. 1279. Submitted June 4, 1952.
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cross yield was high. Fifty to 65 per cent of the variation in yield in different groups of single crosses was explained by the concomitant variation in cob length, diameter, and weight.

Variance component analyses of the measured characters studied in single crosses and their inbred parents showed the relative variances due to genetic and environmental variation. Single cross progenies of inbred parents, highly selected for uniformity of maturity and yield potential in hybrids, had no more than 25 per cent of the variance for these traits attributable to genetic background, general plus specific combining abilities. The chief source of variation, 40 to 78 per cent, was sampling variation, i.e. variation among ears within a genotype pooled among all the hybrids of a group.

Presence and intensity of midcob color, visually classified in red and brown series, was clearly interrelated with silking date, cob weight, breaking strength, and kernel

weight. Intense red pigmentation was associated with higher yield, higher breaking strength, higher cob weight, and later maturity.

Breaking strength, midcob color, cob weight, and silking date can feasibly be incorporated into the early stages of a maize breeding program to speed up isolation of the more preponent genotypes for testing in hybrid combinations. In more advanced stages of the breeding program these same characters can be valuable adjuncts to keep the progress at a high and efficient level.

Pertinent silicon chemistry was briefly reviewed as background for postulating a series of fundamental biochemical steps involving reactions of a silicon complex to account for the interrelationships found in the research reported. The silicon reactions were postulated also as some of the primary synthetic reactions in the plant's manufacture of carbohydrates and proteins and related compounds.

INTENSITY AND EFFECTIVENESS OF SELECTION IN SWINE¹

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The principal purposes of the study were two. First, to measure the intensity of selection applied within 12 inbred lines of Poland China swine at the Iowa Station. Second, to determine whether the selection practiced was effective in improving the performance of the inbred lines. The study also yielded information on how much of the selection for litter characteristics was automatic, on the variation of selected traits, on the generation interval, and on the proportion of males and females retained as parents at the time of first and subsequent selection. The intensity and effectiveness of selection among one, two and four sire lines were contrasted. The traits studied were:

Number of pigs farrowed per litter (NF)
Number of pigs weaned per litter (NW)

Weight of the litter when weaned at 56 days (\overline{WW}_L)

Average weaning weight per pig in the litter (\overline{WW}_{PL})

Weight of the individual pig at 56 days (W_{56})

Weight of the individual pig at 154 days (W_{154})

Net merit as measured by an index (I), wherein $I = 2 (NF) + 4 (NW) + .133 (\overline{WW}_L) + W_{154}$

In addition to these seven performance traits, the inbreeding levels of dams (F_D) and of individuals (F_I) were studied. These showed that the animals selected to be parents tended to be less inbred and out of less inbred dams than their contemporaries which were not used for breeding. Evidently, the performance depressing effects of inbreeding were of such severity that they affected the selections.

The data came from 2357 litters and 9695 pigs weaned in the 12 inbred lines maintained at the Iowa Station during varying numbers of years in the two decades from 1930 to 1950. Selection differentials were computed for young and old

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sires (\bar{S}_1 , \bar{S}_2), for young and old dams (\bar{D}_1 , \bar{D}_2), for all sires (ΔS), for all dams (ΔD) and for both sires and dams (ΔP). Average annual selection differentials for parents (ΔP) among one, two and four sire lines, respectively, were:

.31, .38 and .27 pig for NF
 .62, .72 and .59 pig for NW
 19.51, 22.76 and 23.09 lb. for \overline{WW}_{PL}
 1.91, 2.13 and 2.02 lb. for \overline{WW}_{PL}
 3.12, 3.43 and 3.90 lb. for W_{30}
 12.36, 16.01 and 16.28 lb. for W_{154}
 15.13, 21.11 and 19.50 units for I.

Except for NF and NW the selection averaged a little weaker in the one sire lines, but the differences were small. These values are equal to the total improvement expected in each of these traits in a ten year period, if heritability for each of them amounted to .10. The performance depressing effects of inbreeding would be expected to make the net improvement less than this.

The annual selection differentials over all lines for \bar{S}_1 , \bar{S}_2 , \bar{D}_1 and \bar{D}_2 , when converted to standard measure by dividing them by their corresponding standard deviations, were:

.34, .10, .23 and .14 for NF
 .75, .05, .53 and .28 for NW
 .90, .21, .60 and .27 for \overline{WW}_{PL}
 .52, .14, .36 and .14 for \overline{WW}_{PL}
 .82, .16, .35 and .09 for W_{30}
 .83, .12, .49 and .16 for W_{154}
 .88, .19, .45 and .20 for I.

These selection differentials would have averaged 1.75, .60, 1.08 and 1.12 respectively, for \bar{S}_1 , \bar{S}_2 , \bar{D}_1 and \bar{D}_2 if selection had been by truncation, on one character alone, and restricted to the proportions retained for parents found in this study.

The average age of parents at the time their progeny were produced was:

1.04 for \bar{S}_1
 1.95 for \bar{S}_2
 1.06 for \bar{D}_1
 2.15 for \bar{D}_2
 1.26 for all sires
 1.49 for all dams
 1.38 for all parents.

Automatic selection is that which would be accomplished if young boar and gilt replacements were saved from every litter in proportion to the size of the litter. It accounted for 84 per cent of the total selection for NF, 75 per cent for NW, 60 per

cent for \overline{WW}_{PL} and 49 per cent for \overline{WW}_{PL} . The absolute values of the automatic selection differentials in the one, two and four sire lines were:

.28, .29 and .29 pig for NF
 .54, .56 and .54 pig for NW
 14.02, 14.90 and 16.48 lb. for \overline{WW}_{PL}
 1.30, 1.28 and 1.00 lb. for \overline{WW}_{PL} .

Performance levels over all lines and for all seven of the performance traits declined, despite selection for net merit amounting to 50.3 per cent of the maximum selection achievable for \bar{S}_1 , 31.7 per cent of the maximum achievable for \bar{S}_2 , 41.7 per cent of the maximum achievable for \bar{D}_1 , and 17.9 per cent of the maximum achievable for \bar{D}_2 .

The average annual decline in levels of performance during the period 1939-1947 among the one, two and four sire-lines was:

-.17, -.27 and -.07 pig for NF
 -.25, -.33 and -.13 pig for NW
 -9.43, -13.76 and -5.27 lb. for \overline{WW}_{PL}
 -1.16, -1.72 and -.92 lb. for \overline{WW}_{PL}
 -.79, -1.11 and -.35 lb. for W_{30}
 -2.61, -2.52 and -1.63 lb. for W_{154}
 -5.26, -5.88 and -2.32 units for I.

The declines were less in the four sire line, but they were not significantly so. Differences in this respect were even smaller between the one sire and the two sire lines. Average decline in performance for each 10 per cent increase in inbreeding was greater for NF and NW in seven of the twelve lines than could be accounted for by the effects of inbreeding depression alone. Nine of the twelve lines declined more in 154 day weight than could be accounted for by inbreeding depression despite strong selection for heavier weight at 154 days.

Positive selection was followed by a decline in performance beyond that expected to be caused by the inbreeding. Among possible reasons for the failure of selection to achieve expected improvement in the performance levels of these inbred lines, negative genetic correlations between traits and overdominance in many gene loci seemed most plausible.

In the light of these findings the breeding plans which seem most promising for improving the net merit of swine populations are somewhat like those now used for the production of hybrid corn. The steps involved in such plans are:

1. Form many distinct families (inbred lines) rapidly.
2. Cull a large proportion of the families and start new ones as soon as linecross data have been secured and evaluated.
3. Utilize families proven most profitable in linecrosses for the production of market hogs. The most efficient use of such families may involve a system of rotation crossbreeding or the use of com-

binations of lines in a manner analogous to present practices for the production of hybrid corn. It seems reasonable to expect that the female parents involved in the production of market hogs must be the product of crossing two or more inbred lines if their litters are to escape the effects of the lowered performance levels of inbred dams.

EXTENSION OF NORMAL THEORY TO GENERAL MATRICES¹

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An analogy between a polynomial in an arbitrary nonsingular real matrix A of degree n with distinct characteristic roots and the conjugate transpose of a normal matrix is demonstrated which is useful in obtaining the characteristic roots by algebraic operations in the real field. A matrix A which satisfies the above conditions is called a general matrix.

If A is general, there exists a positive definite hermitian matrix H such that $HAH^{-1} = N$, where N is normal. As a consequence of this fact, one can derive a unique real polynomial $p(A)$ of degree at most $n-1$ such that $JA J^{-1} = p(A')$, where $J = H^*$.

To a large extent the polynomial $p(A)$ plays the same role with respect to the general matrix A as the conjugate transpose N^* does with respect to the normal matrix N . That is, the characteristic roots of $A + p(A)/2$, $A - p(A)/2i$, and $Ap(A)$ are respectively the real parts, the imaginary parts, and the squares of the moduli of the roots of A .

To further study the polynomial $p(A)$, the algebra $R(A)$ of all real polynomials in A is considered. The polynomial $p(A)$ is similar to A and determines a special automorphism of $R(A)$. If $TAT^{-1} = \Lambda$ is diagonal, then $Tp(A)T^{-1} = p(\Lambda) = \bar{\Lambda}$. Among the elements of $R(A)$ which are similar to A , only $p(A)$ has the property that $p(\Lambda) = \bar{\Lambda}$. Another important property is that $p[p(A)] = A$ so that A

$\langle - \rangle p(A)$ determines an involutory automorphism of $R(A)$.

It is shown that every real matrix B with linear elementary divisors which prime commutes with a positive definite hermitian matrix C , that is, $CB = B'C$, has real characteristic roots. Therefore, since $JA J^{-1} = p(A')$, one finds that the matrix $A + p(A)$ prime commutes with J . Thus $J[A + p(A)] = [A' + p(A')]J$. The matrix $Ap(A)$ also prime commutes with J . In fact, it readily follows that all elements of $R(A)$ which prime commute with J form a sub-algebra $H(A)$ consisting of all elements of $R(A)$ which have real characteristic roots and conversely.

If the matrix A has characteristic roots with real parts of the complex roots distinct from the real roots and each other, and imaginary parts distinct, then I , $(A + P)$, $(A + P)^2, \dots, (A + P)^{n-k-1}$, $(A - P)$, $(A - P)^2, \dots, (A - P)^{n-k-1}$ is a basis for $R(A)$, where k is the number of pairs of complex roots and $P \equiv p(A)$. It can be shown that the even elements, that is, I , $(A + P)$, $(A + P)^2, \dots, (A + P)^{n-k-1}$ are a basis for the algebra $H(A)$. The odd elements, $(A - P)$, $(A - P)^2, \dots, (A - P)^{n-k-1}$ are a basis for the vector subspace $K(A)$ of $R(A)$ where each element $k_1(A)$ has pure imaginary characteristic roots.

The matrix A has distinct characteristic roots but may not satisfy the other conditions of the preceding paragraph. In that case, one may use powers of AP and $A^2 - P^2$ as basis-elements of $R(A)$. The automorphism $A \langle - \rangle p(A)$ is the only one other than the identity which leaves the elements of $H(A)$ elementwise invariant.

1 a. Chairman of Committee, B. Vinograd, Dept. of Mathematics.

b. Doctoral Thesis No. 1199. Submitted July 20, 1951.

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It is shown that when the algebra $R(A)$ and the isomorphic algebra $R(A')$ have non-trivial elements in common, they have non-trivial symmetric elements in common.

For the second, third, and some fourth order matrices, the polynomial $p(A)$ can be constructed directly by solving the matrix equation $p[p(A)] = A$ for the coefficients of $p(A)$. This method is impractical for higher order cases. To obtain the polynomial $p(A)$ in the higher order cases it is helpful to obtain a basis for the algebra $H(A)$. The details of obtaining an idempotent basis for $H(A)$ by solving a

polynomial for real roots or by solving a system of n simultaneous quadratic equations in n unknowns are given. Newton's method of iteration is suggested for the latter system. It is shown that the functional determinant of this system does not vanish at the solutions. Furthermore, a simple method for writing down the system of quadratic equations is given which involves the use of the columns of the powers of the rational canonical form of A .

A simple method is given for the construction of $p(A)$ in terms of an idempotent basis for $H(A)$.

EVALUATION OF FARM BUILDINGS AS A FACTOR IN AGRICULTURAL PRODUCTION¹

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The analysis of farm buildings as a production factor in agriculture embraces two separate but closely related fields, agricultural economics and agricultural engineering. In striving to clarify and delineate production theory appropriate to farm structures, the farmer is, at the outset, assumed to be an entrepreneur with a primary interest in the maximization of profits. The lack of information pertaining to building input-output relationships, practical methods of determining and keeping in balance the optimum division of the total building outlay between competing enterprises, and the relation between building expenditures as fixed costs and unit costs at varying levels of output, are cited as factors, essentially in the field of agricultural economics, which necessarily limit the present study.

Similar factors of importance in the field of agricultural engineering not treated in the study include:

1. Need for more precise specifications on the part of technologists as to optimum environmental conditions which the building should provide.

2. Planning problems incident to the relatively long life of farm buildings as compared with the brief, average tenure period of farm operators.

3. Slowness with which new and improved designs and methods of construction are translated to the field.

4. Shortage of qualified workers in the farm structures field.

Yearly capital inputs are computed for two alternative arrangements for dairy and swine housing. By the use of a going interest rate of five per cent, the analysis indicates the increasing magnitude of the input as anticipated returns are projected over the life of a short-lived versus a long-lived building. The significance of an assumed daily saving in labor is demonstrated and the possibility presented that this feature might well be the deciding factor in the making of recommendations between long- and short-lived buildings. Following a brief treatment of the importance of capital rationing, the analysis is repeated employing a capital productivity rate in agriculture taken arbitrarily as 12 per cent. This procedure lends increased emphasis to the high cost of yearly capital inputs when projected over the life expectancy of a long-lived building as compared with a shorter-lived one even though the original annual capital input in the latter may be substantially higher. Capitalization of building capital inputs at an interest rate

1 a. Chairmen of Committee, Henry Giese, Dept. of Agricultural Engineering, and Earl O. Heady, Dept. of Economics and Sociology.
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representative of the capital productivity within the farm operation is a more realistic approach than employing a rate of interest as charged by loaning agencies. This in no manner minimizes the labor-saving features provided by the building particularly if the value of the labor saved is placed in the business and allowed to earn at the capital productivity rate.

Assumed building production functions are used to indicate, by means of a derived transformation curve, the marked difference which will exist in the division of building resources between enterprises by two farmers with different amounts of available building capital. Implications of the analysis suggest that the flexible building arrangement is of more importance to the farmer with limited building capital than in the case of the farmer with greater resources.

The division of building investment between competing enterprises is considered, employing both long- and short-run concepts. Two enterprises are arbitrarily selected, based first on decreasing returns, and second, on increasing returns to the building investment; the optimum division of building resources is determined based on historical price ratios. Relationships between short- and long-run planning curves are emphasized particularly with regard to the flexible and inflexible plants. In analyzing deviations between the long- and short-run planning curves, building arrangements involving a high degree of specialization are of major importance especially in operating schemes involving competing livestock enterprises. For two enterprises exhibiting increasing returns to building investment over a significant range of output, the division of such building resources between the two enterprises is determinate, and such a division once properly com-

puted will not likely change appreciably with varying price ratios between the two enterprises.

Building flexibility is considered in detail in the final section. Aspects of uncertainty may enter heavily into the farmer's expectations and the lesser productivity of the flexible plant overtime, as viewed in light of his expectations, may be considered worthwhile as a hedge against price relationships which possibly might prove more erratic in the future than in the past. Short-run planning curves between the hog and the poultry enterprises are derived based essentially on established space requirements. The inflexibility of the small poultry housing unit is compared with the relative flexibility of the central type hog housing unit. The analysis considers in the first instance the case of the farmer with moderate building resources, and secondly, the farmer with limited building capital. Specialized equipment, labor more skilled in one enterprise than another, and the personal preference of the operator as to the nature of the enterprise to be conducted are factors which would tend to retard accentuation of commodity cycles even though the farm building was highly flexible. Practical aspects of flexibility are indicated including the stable relationship which likely exists between hog and poultry production on Iowa farms producing hogs as a main enterprise.

Activities of the Midwest Plan Service relating to the provision of increased flexibility in farm building plans are reviewed. A specific example is given. Despite limited enthusiasm on the part of farm structures specialists and farmers to date, work of this kind may well be a point of departure from which increased flexibility in farm buildings may be ultimately achieved.

FERTILITY, PARENT-PROGENY, AND PROGENY TEST COMPARISONS OF SELECTED CLONES OF ORCHARDGRASS, *DACTYLIS GLOMERATA* L.¹

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Investigations involving 19 clones of orchardgrass, *Dactylis glomerata*, concerned evaluations and interrelationships of fertility, agronomic performance, and combining ability. Fertility comparisons involved methods of determination, years, and modes of pollination. Parent-progeny and interprogeny comparisons and relationships among fertility, vigor, and combining ability also were studied. Data obtained from all possible single crosses among 11 clones were used to estimate mean variances of general and specific combining ability and to estimate the effect of varying numbers of testers upon mean variance of general combining ability. Fertility, clonal, and progeny evaluations were made in 1949 and 1950, 1950 and 1951, and 1951, respectively.

Seed set under bag and under open-pollination was sampled in a crossing block in which each clone appeared 19 times. Two selfed panicles in 1949, one selfed panicle in 1950, and one open-pollinated panicle from each year were obtained for most of the 19 locations of each clone within the crossing block. Panicle size was maintained as a constant insofar as the material would allow. Self-fertility ranged from 1.0 to 70.2 and from 1.4 to 59.4 germinable seeds per 100 florets for 1949 and 1950, respectively. Corresponding ranges for cross-fertility were 57.2 to 84.4 and 51.6 to 81.4 germinable seeds per 100 florets. Self- or cross-fertility measurements of germinable seed per 100 florets, germinable seed per panicle, and plump seed per panicle generally were indicative of one another. Correlations of selfed seed set between germinable seeds per 100 florets and weights of threshed seed and weights of unthreshed panicles were 0.83 and 0.81, respectively. Variation present in panicle

size was not an important factor in determining selfed seed set. Interannual correlations for self- and cross-fertility determined as germinable seeds per 100 florets were 0.86 and 0.50, respectively. The correlation between selfed and open-pollinated seed set (germinable seeds per 100 florets) was 0.12 for 1949 and 0.56 for 1950.

Parental clones were evaluated in replicated tiller beds for one or two years for early spring vigor, date of blooming, panicle production, disease susceptibility, green and dry forage yields, height, leafiness, recovery after first cutting, and leaf width. Clones differed in all characters except date of blooming. Early spring vigor, panicle production, forage yield, recovery after first cutting, and leafiness were associated positively with one another and negatively with date of blooming and leaf width. Height seemed independent of any character measured. Disease susceptibility was suspected of being confounded with nitrogen deficiency. Interannual associations for characters measured both years indicated considerable variation between years. Green forage yield of a given genotype was highly indicative of its dry forage yield.

All progenies were planted in broadcast plots in a single experiment consisting of three replications of a completely randomized block design. Entries consisted of 141 of the possible 171 single crosses among 19 clones, two polycross entries for each clone, and one topcross entry per clone. Loss of single crosses was considered random. Progenies were evaluated for early spring vigor, date of blooming, number of panicles, disease susceptibility, and green forage yield. Single crosses differed significantly for all characters measured, but significant differences among polycrosses existed only for disease susceptibility and dates of blooming. Topcrosses differed significantly only for dates of blooming. Parent-progeny associations were usually positive but not of sufficient magnitude to forego progeny testing. Correlations between progeny tests were all positive, many

1 a. Chairmen of Committee, Robert R. Kalton, and I. J. Johnson, Dept. of Agronomy.
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significantly so. The magnitude of interprogeny associations seemed dependent upon the number of plots determining a progeny mean. Correlations between mean single cross and polycross performances were in general the highest of interprogeny associations and ranged from 0.40 for early spring vigor to 0.86 for disease susceptibility. Intraclass correlations between duplicate polycrosses indicated that genetic variation among clonal polycross means was relatively small compared to environmental variation.

Correlations between self- or cross-fertility of parental clones and their vigor (number of panicles and green forage yield) ranged from -0.29 to 0.11 and offered no evidence of an association. Correlations between self- or cross-fertility of clones and their combining ability (as measured by mean single cross, polycross, and topcross progeny performance for number of panicles and green forage yield) varied from -0.35 to 0.37 and were interpreted as estimates of zero. There was some suggestion of a positive association between open-pollinated seed set of parents

and maturity of both parents and progenies. All 12 of such correlations were positive and four exceeded the 5 per cent level of probability.

All possible single crosses among 11 clones were utilized in obtaining estimates of mean general and specific combining ability variance by analyses of variance of early spring vigor scores, dates of blooming, panicle numbers, disease susceptibility scores, and green forage yields. Mean general combining ability variance was greater than mean specific combining ability variance for all characters studied. Components of variance were used to estimate the effect of varying number of testers and replications upon mean general combining ability variance. An increase in number of testers was more efficient than an increase in number of replications. With three replications, five testers were required for approximately 80 per cent information relative to mean general combining ability variance. This assumed that 100 per cent information was obtained with ten testers.

OVERLAPPING PFAFFIANS WITH APPLICATION TO UTILITY THEORY¹

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This paper considers the properties of those Pfaffian forms for which the bilinear covariant matrix, A , has a special structure. Most of the results concern the case where the matrix, A , which is of course skew-symmetric, has one super-diagonal stripe. This particular structure usually is a consequence of the choice of variables which appear in the coefficients of the Pfaffians herein treated. The principal results depend on relations among overlapping sub-Pfaffians, hereafter called Pfaffian chains.

A preliminary study of the possibility of common class among Pfaffian chains in general Pfaffians indicates that class two is difficult to achieve under some circumstances. Therefore, integrability is imposed

upon overlapping Pfaffian chains of length three and the coefficients restricted enough to make feasible an analysis of the possibility of common class two.

For the Pfaffian chain

$$w_{i+t} = \sum_{j=i+t}^{i+t+2} X_j dx_j,$$

where the $X_j = X_j(x_{j-1}, x_j, x_{j+1})$ have continuous second order partial derivatives, the integrating factor, u_{i+t} , is assumed to be free of x_{i+t} , and consequently of x_{i+t+2} . It turns out that this restriction is not as severe as one might expect. Following are some of the results which are obtained from such an assumption regarding integrating factors:

Theorem 1. If u_i and u_{i+1} are respective integrating factors of w_i and w_{i+1} , where

- 1 a. Chairman of Committee, B. Vinograd, Dept. of Mathematics.
- b. Doctoral Thesis No. 1254. Submitted March 13, 1952.
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the X_j are not identically zero, such that u_i is free of x_i and u_{i+1} is free of x_{i+1} , then

$a_{i, i+1}$ is free of x_{i+2} ,

$a_{i+1, i+2}$ is free of x_i and x_{i+3} ,

$a_{i+2, i+3}$ is free of x_{i+1} .

Conversely, if the above conditions on the a_{rs} are satisfied and w_i and w_{i+1} are integrable, then there exist a u_i free of x_i and a u_{i+1} free of x_{i+1} .

Corollary 1. If the X_j of Theorem 1 are linear functions the conditions of Theorem 1 are always satisfied, hence the integrability of w_i and w_{i+1} is equivalent to the existence of a u_i free of x_i and a u_{i+1} free of x_{i+1} .

Corollary 2. If the X_j of Theorem 1 are quadratic functions the conditions of Theorem 1 are satisfied if, and only if, the terms $x_j x_{j+2}$ do not appear in X_{i+1} and X_{i+2} . Hence, if w_i and w_{i+1} are integrable, the non-appearance of the terms $x_j x_{j+2}$ in X_{i+1} and X_{i+2} is equivalent to the existence of a u_i free of x_i and a u_{i+1} free of x_{i+1} .

Theorem 2. Consider the three overlapping Pfaffian chains w_{i-1} , w_i , w_{i+1} , where the X_j are quadratic functions. If these chains satisfy the conditions of integrability, then the further condition that the coefficient of the term $x_j x_{j+2}$ in X_{i+1} is non-zero forces at least two identically-zero coefficients among X_{i-1} , X_i , X_{i+2} , X_{i+3} .

Corollary. For the chains of Theorem 2, with the X_j not identically-zero, there exist, in light of Corollary 2 of Theorem 1, integrating factors of the type described in Theorem 1.

Theorem 3. Let the conditions of integrability be imposed on the separate Pfaffian chains w_{i-2} , w_{i-1} , w_i , w_{i+1} , w_{i+2} , w_{i+3} , where the X_j are not identically-zero. Then, when u_{i+t} can be chosen free of x_{i+t} , the Pfaffian chains are exact. Hence, such overlapping chains cannot have a common class number less than or equal to two, that is, be integrable, unless the

Pfaffian form of length eight is itself exact.

Corollary. Under the conditions of integrability of the six Pfaffian chains of Theorem 3, if the a_{rs} can be chosen as in Theorem 1, then the corresponding Pfaffian chain of length eight is exact. In particular this applies to the quadratic case in Theorem 2.

It is easily proved that the imposition of integrability on the w_{i+t} also implies exactness of the whole Pfaffian form when the length of w_{i+t} is greater than three. Using a type of Pfaffian chain in which the variables form a complete cycle, that is, $X_j = X_j(x_j, x_{j+1})$ except for the last coefficient, which may involve the first variable of the chain, a result similar to that in Theorem 3 is obtained. Other results are obtained in cases where non-adjacent variables are used in the coefficients. The possibility of a fluctuating class for Pfaffian chains but common class for the corresponding Pfaffian chain equations is also treated.

Properties of the above types of Pfaffians are then applied to utility theory in economics. The distinction between integrability and non-integrability is considered as a distinction between rational and irrational behavior on the part of the consumer. Make the general hypotheses: (a) A consumer will be rational in an economic transaction if the number of variables involved is sufficiently (but not trivially) restricted, and (b) a consumer cannot only order the variables of the above transaction and therefore group them in harmony with such an order, but there exists an ordering such that he can deal rationally within the groups provided the size of the groups is less than four. Then, the following conclusions are drawn: (a) The consumer's utility Pfaffian in general is not only integrable (in the large) but is exact, and (b) the implication is that the behavior of the consumer in the large is rational in general.

TRICHLOROETHYLENE EXTRACTION OF COTTONSEED¹

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Experimental work has shown that the color fixation of the trichloroethylene extracted cottonseed oil processed at usual temperatures cannot be removed by the ordinary refining method. In order to avoid the color fixation, processing conditions of cottonseed oil miscellas should be maintained at a lower temperature. It is therefore important to have data on the boiling points of cottonseed oil-solvent miscellas at reduced pressures. The boiling points of crude cottonseed oil-trichloroethylene miscellas of different compositions at various reduced pressures were determined and plotted as smooth curves. Curves of vapor pressure-composition relationships at constant temperature and boiling point-composition relationships at constant vapor pressure have been plotted from the boiling-vapor pressure curves at the constant composition.

A modified procedure of 90 minutes cold stirring with the foots chilled at 10°C. was used in the refining of the trichloroethylene extracted cottonseed oil, resulting in firm foots and a lighter oil color with a slight increase in the refining loss.

The solvent, trichloroethylene, was removed from the dilute cottonseed oil miscella by means of a laboratory rising film evaporator and packed column stripper operated at reduced pressure. The effect of heat on the color of the cottonseed oil produced from this miscella at

110°, 130°, 150°, 180°, 210° and 240°F. was determined. The optimum operating temperature for the processing of trichloroethylene extracted cottonseed miscella was found to be 150°F., at which temperature a crude oil was secured from which a prime refined and bleached cottonseed oil was produced. A slightly improved oil color was obtained when the miscella was processed at a temperature below 150°F. When miscella was processed at 180°, 210° or 240°F., both the refining loss and the oil color increased rapidly with the temperature and the heating time.

If the trichloroethylene-cottonseed oil miscella is to be concentrated to 90 per cent oil before going to stripper, it is recommended that the rising film evaporator be operated at an absolute pressure of 1.5 inch Hg. The stripper should be maintained at an absolute pressure of 6 to 7 inch Hg. in order to strip with steam having a temperature not above 150°F.

Bleached prime hydraulic pressed cottonseed oil containing 0.00, 0.01, 0.02, 0.05 and 0.1 per cent of trichloroethylene was hydrogenated, but it was found that the trichloroethylene was poisonous to the nickel catalyst used in the hydrogenation. When 0.02 and 0.05 per cent trichloroethylene were added to two samples of crude hydraulic pressed cottonseed oil and the oil refined, washed, dried, bleached and hydrogenated, no poisonous effect on the nickel catalyst was found. This was due to the fact that the trichloroethylene was removed by the process of refining, washing, drying and bleaching.

The experimental work indicates that trichloroethylene can be used as a solvent to extract cottonseed oil which will meet the commercial standard of quality.

- 1 a. Chairman of Committee, Joseph M. Keller, Dept. of Physics.
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PREPARATION OF VANADIUM METAL¹

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Vanadium metal in the massive form was prepared by calcium reductions of vanadium pentoxide, vanadium trioxide, vanadium trifluoride and vanadium trisulfide. The exothermic chemical reduction was carried out in closed iron bombs lined with dolomitic oxide refractory. A secondary reaction between a sulfur booster reagent and excess reductant furnished auxiliary heat and gave a product capable of lowering the melting point of the slag. This allowed better agglomeration of the metallic phase. On the scale investigated, metal thus reduced collected in a solid regulus weighing about 70 grams. Some of the metal produced was ductile, and could be cold rolled to thin sheets.

From vanadium pentoxide, available commercially in the chemically-pure and technical grade forms, other vanadium compounds utilized in the reduction process were prepared. Vanadium pentoxide was reduced to vanadium trioxide with hydrogen at 700°C. Vanadium trifluoride was prepared by passing anhydrous hydrogen fluoride over vanadium trioxide at room temperature, followed by drying of the hydrated trifluoride at 300°C. in an atmosphere of hydrogen fluoride. Vanadium trioxide was converted to vanadium trisulfide by reaction with hydrogen sulfide at 800°C.

The reduction charge, containing the compound to be reduced, the reductant and the booster reagent, was thoroughly mixed and packed in the refractory-lined metal bomb. After the bomb was capped, the reaction was initiated by heating the bomb assembly in a gas-fired furnace. The course of the reaction was followed by measuring the temperature of the outside of the bomb. After the reaction had fired and the bomb had cooled, the reaction products were removed with a chisel and leached in water and dilute acid. The regulus recovered generally contained 75—80 per cent of the vanadium and was indicated to be of high purity.

The use of sulfur in the reaction charge made possible the successful reduction to massive metal of technical grade vanadium compounds as well as those of higher purity. Reductions from technical grade compounds were shown to represent an appreciable saving in cost in comparison with reductions made from chemically-pure vanadium compounds. A large excess in calcium gave best results from the standpoint of recovery and hardness of metal. Of the lower purity vanadium compounds reduced, the trifluoride furnished the highest biscuit yields, while the trioxide supplied the softest metal. Only metal obtained from the oxides was found to be ductile. A typical trioxide reduction charge for a two and one-half inch diameter bomb contained 150 grams of technical grade vanadium trioxide, 256 grams of calcium and 50 grams of sulfur. The practical use of larger bombs with larger charges was demonstrated.

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RADIATION- AND LAG-ERRORS IN THE MEASUREMENT OF TURBULENT TEMPERATURE FLUCTUATIONS¹

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This investigation was carried out in order to determine the magnitudes of certain errors due to radiative heating and to instrument lag which were expected to create the principal measurement problems in a study of turbulent fluctuations of air temperature in the natural wind. This study, of which the present investigation is an integral part, is being made with the support of the Base Directorate for Geophysical Research, Air Force Cambridge Research Laboratories, under contract No. AF19 (122)-440.

The radiation- and lag-errors of two particular thermal sensing elements were analysed: the Western Electric D-176980 bead-type thermistor, and a copper-constantan thermocouple of 0.0025-centimeter diameter. Both provide electrical signals that facilitate rapid automatic recording of their temperature indications, and both are physically small enough that their radiative heating and lag in response are quite low by comparison with such conventional sensing elements as the mercurial thermometer. The relative merits of these two most-suitable sensing elements were examined in as complete a fashion as was possible with available experimental data.

The radiative heating of a Western Electric D-176980 bead-type thermistor was determined by calculation of the contributions of direct solar radiation, diffuse sky radiation, ground-reflected radiation, and infrared radiation. Using laboratory determinations of the dissipation rate of the bead thermistor, the radiation errors to be expected under a number of different conditions were computed. It was concluded that although the thermistor will develop a steady-wind radiation error of the order of 1 C° near noon on a clear summer day, the vertical variation of the error for thermistors mounted at a series of

heights above the ground will be small enough (few per cent) to be neglected in lapse rate determinations. Furthermore, and of greater direct importance in fluctuation studies, it was concluded that the errors of confounding of wind speed fluctuations with temperature fluctuations will be low enough compared to the true fluctuations (order of 10 percent) that they are not prohibitive to the use of the bead thermistor in fluctuation investigations.

An analysis of radiation errors of a thermocouple of 0.0025 cm. diam. was carried out in a similar manner. Because of marked disagreement among previously published studies of the dissipation rates of small wires, it was emphasized that no firm conclusions could be drawn, but on the basis of the dissipation rates determined from an equation given by King (1914), tentative error values were computed. These suggest that thermocouples of the size considered may suffer appreciably lower radiation errors than the bead thermistor, possibly only about 10 per cent as large. The advantage of much greater signal voltages from the thermistor than from the thermocouple and the fact that even the thermistor errors are not intolerably large, make the thermistor the more desirable sensing element for use in fluctuation studies. An examination of the benefit derivable from applying a high-albedo coating to the thermistor bead suggests that thermistor radiation errors might be reduced by 90 per cent if a silver or aluminum film could be deposited successfully on the bead.

The effects of instrument lag were analysed on the basis of the differential equation of response of a lagging element. Several general relationships between the true and the apparent fluctuation statistics (mean, variance, correlation coefficient) were derived and quantitative determinations of certain lag errors of the bead thermistor carried out. It was concluded that the bead thermistor will respond in a biased manner to the range of turbulent fluctuation periods predicted to be present in the natural wind (0.1

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second to 100 seconds, approximately). This bias takes the form of marked attenuation of the shorter-period fluctuations in the range of interest. Electrical lag compensation of the thermistor output seems essential if this element is to serve in the exploration of the full spectrum of atmospheric turbulence.

The lag times of a thermocouple of 0.0025 centimeter diameter, as computed from the King equation, were found to be less than one-tenth as great as those experimentally determined for the thermistor. The uncertainty of the validity of

using the King equation to predict the dissipation rates of thermocouples carries over into the lag-time calculations, so it is not felt that any final conclusions as to the relative merits of thermistor and thermocouple should be drawn. Further experimental study of the dissipation rates of wires at room temperatures is essential to any further analyses of thermocouple radiation- and lag-errors. The anomalous results of Ayrton and Kilgour (1892) raise questions which particularly need attention.

THE TURKEY AS A HOST FOR *PLASMODIUM LOPHURAE* COGGESHALL, 1938¹

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The present studies were undertaken to determine the status of the turkey as a host for *Plasmodium lophurae*. Among the subjects studied were: (1) age of turkeys and dosage of infection, (2) biological characteristics and host-parasite relationships, (3) merozoite production, survival and death rates of the parasite during the course of the primary infection and relapse, (4) immunity, and (5) exoerythrocytic stages.

The method of study is described and on the bases of the data obtained the following conclusions are drawn:

(1) Age resistance did not develop in turkeys up to 32 days of age.

(2) Dosages of from 0.5 to 2.6×10^8 parasitized cells per 100 g. of a bird's body weight proved satisfactory for the study of the parasite in turkeys.

(3) The degree of synchronicity of the cycle stages *P. lophurae* was low in the turkey. The length of the asexual cycle was established at 36 hours.

(4) The majority of the merozoites that survived succeeded in penetrating new red cells without discriminating against immature erythrocytes.

(5) In ducks infected with parasitized

duck erythrocytes, the length of asexual cycle was established at 36 hours, 39 hours in turkeys infected with parasitized duck erythrocytes, and 36 hours in the turkeys infected with parasitized turkey erythrocytes. In turkeys with fatal infections, shortening of the length of the last asexual cycle prior to death was indicated, in these cases from the usual 36 hours to 27 hours.

(6) In general there was little difference in cloacal temperatures between the parasitized and unparasitized turkeys for the first to the fourth or fifth days after inoculation. Sub-normal temperature preceded death.

(7) The over-all survival rate of the parasite was low for the first segmentation of the initial infection, about 26 per cent of the 13-16 merozoites produced per segmenter. There was a gradual decline in survival rate in succeeding segmentations until the average number of merozoites that survived per segmenter was less than 1. Similar observations were noted in relapses. Furthermore, the parasite survival was proportionally reflected in the intensity of relapse.

(8) Acquired active immunity developed progressively against *P. lophurae* in turkeys.

(9) Immune duck plasma exerted an initial sparing action in behalf of the parasitized duck cells injected into turkeys, and it conferred on the host partial protection against the primary attack after the sparing effects ceased to be apparent.

- 1 a. Chairman of Committee, Elery R. Becker, Dept. of Zoology and Entomology.
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Immune turkey plasma conferred partial protection on the host injected with parasitized duck cells throughout the general course of infection, but there was no sparing effect.

(10) From the daily growth gains of the birds used in immunity experiments, there was no evidence which suggested that the plasma-recipients made less growth gains than their controls. Thus, the possibility of sparing action being due to the result of a state of intoxication produced in the host was ruled out.

(11) The present study in turkeys is in full accord with the previously reported sparing effect of duck plasma on duck cells injected into chicks.

(12) Phanerozoites of *P. lophurae* occurred in the brains of turkeys from the 15th to the 24th days after infection of the host. The greatest intensity of exoerythrocytic stages in the brain occurred about the 19th day after infection. The exoerythrocytic stages occurred in turkeys that had survived the primary erythrocytic infections and, in some cases, one relapse.

DETERMINATION OF SOURCE AND DISTRIBUTION OF P_2O_5 IN TRIPLE SUPERPHOSPHATE BY RADIOACTIVE PHOSPHORIC ACID¹

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The optimum proportion of phosphoric acid to phosphate rock for the manufacture of triple superphosphate has been determined empirically by the industry. This proportion is in excess of that stoichiometrically needed to form monocalcium phosphate, but insufficient to produce complete availability of the P_2O_5 in the superphosphate. It has not been known whether the unavailable P_2O_5 in the superphosphate is unreacted rock phosphate or a reverted form of phosphate, nor has the distribution of acid P_2O_5 in the superphosphate been known. It was believed that a better understanding of the reactions involved in triple superphosphate manufacture would provide a basis for improvements.

An investigation of the distribution of acid P_2O_5 and rock P_2O_5 in triple superphosphate was undertaken to more clearly define the reactions involved. P^{32} was used in tracing the ultimate distribution of the reacted acid in triple superphosphate.

Phosphoric acid of concentrations from 60 to 80 per cent H_3PO_4 and containing a small amount of P^{32} as a tracer was reacted with rock phosphate to produce triple superphosphate. A Florida land pebble phosphate rock containing 32.7 per cent P_2O_5 was used. The reaction was conducted at various degrees of acidulation, and the

products were allowed to cure for various periods of time from 0 to 28 days under various conditions of temperature and humidity.

Regardless of acidulation, 95-98 per cent of the acid P_2O_5 was always found in the water soluble fraction, which is generally considered to be principally monocalcium phosphate; 2-5 per cent of the acid P_2O_5 was found in the citrate soluble fraction. None of the acid P_2O_5 was found in the citrate insoluble fraction.

The distribution of the rock P_2O_5 was found to depend on the acidulation. With increasing acidulation, the water soluble portion increased while the citrate soluble and insoluble portions decreased. At the maximum conversion attained for a given acidulation, however, the distribution was always essentially the same for all superphosphates. For example, at an acidulation of 2.4 pounds of acid P_2O_5 per pound of rock P_2O_5 , the maximum conversion was 98-99 per cent, and 90-93 per cent of the rock P_2O_5 was in the water soluble fraction, 6-8 per cent in the citrate soluble fraction and 1-2 per cent in the citrate insoluble fraction.

The P_2O_5 in the citrate insoluble fraction is concluded to be entirely from unreacted rock for every condition investigated. The P_2O_5 in the citrate soluble fraction is concluded to be from two sources, (a) the rock phosphate in some available form such as β -tricalcium phosphate, and (b) the water soluble fraction, from which certain citrate soluble compounds are formed

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on curing, possibly phosphates of iron and aluminum. Upon curing, the ratio of acid P_2O_5 to rock P_2O_5 in the citrate soluble fraction increased with increasing acidulation from approximately 0.3 at acidulation 1.4 to approximately 2.0 at acidulation 2.4. The P_2O_5 in the water soluble fraction is concluded to be principally monocalcium phosphate from both rock and acid P_2O_5 and includes a very small amount of free acid, in most cases less than 0.5 per cent of the P_2O_5 present. After maximum conversion was attained at each acidulation up to 2.6 (at which 100 per cent conversion was attained) the ratio of acid P_2O_5 to rock P_2O_5 in the water soluble fraction was approximately 2.6 in all cases investigated. This is higher than the ratio of 2.0 required for formation of monocalcium phosphate and is explained by reaction of acid with impurities of the rock such as calcium carbonates and fluorides, and iron and aluminum compounds.

For any particular acidulation, the concentration of the reactant acid had no effect on the maximum conversion which could be attained. At an acidulation of 2.4 a maximum conversion of 98-99 per cent was found for all acid concentrations used. An acidulation of 2.2 was required for 95 per cent conversion.

Curing was determined to be a function of the loss of moisture. It was a function of time only as the loss of water was related to time. Maximum conversion was found in all cases when the moisture content was reduced to between 1.5 and 2.5

per cent in the product. A further reduction of moisture below this critical amount always resulted in a loss in P_2O_5 availability or an apparent loss in conversion of from 1 per cent to as great as 14 per cent. This reversion, however, was found to be wholly from a loss of rock P_2O_5 in the citrate soluble fraction. Reversion was also experienced at higher moisture contents in cases where the samples were sealed from the atmosphere while curing. Reversion is speculated to be the formation of an apatite from β -tricalcium phosphate.

In superphosphates produced with 75 per cent H_3PO_4 , maximum conversion was attained at each acidulation without a curing period. A possible explanation is that 75 per cent H_3PO_4 may be sufficiently dilute to permit good mixing yet sufficiently concentrated to result in a relatively dry product when the superphosphates were mixed and ground according to the procedure used in this investigation.

Curing at temperatures of $150^\circ F.$ did not affect the superphosphates, the composition and distribution of P_2O_5 being the same as for superphosphates cured at room temperature. However, curing at temperatures of $284^\circ F.$ materially altered the composition and distribution of P_2O_5 . Up to 14 per cent of the total P_2O_5 changed from the water soluble fraction to the citrate soluble fraction of the superphosphates. No more reversion was caused than was experienced by curing at room temperature.

BACTERIAL METABOLISM OF PENTOSE AND PENTOSE NUCLEOSIDES¹

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Cell-free extracts of *Proteus morganii* have been obtained which can deaminate adenosine. The enzyme preparation has been partially purified and found to be highly specific in its deaminating activity. Nucleosides closely related in structure to

adenosine were not deaminated nor did they interfere with the deamination of adenosine. The bacterial enzyme behaved similarly in many respects to the deaminase of animal origin. The deamination of adenosine in aqueous solution by *Pr. morganii* followed first order kinetics. The optimum pH range was narrow with an optimum at pH 7.8. The Michaelis constant was 17.5×10^{-5} .

Ribose was metabolized by *Escherichia coli* and *Micrococcus pyogenes* var. *aureus* in the phosphorylated state. The catabo-

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- b. Doctoral Thesis No. 1201. Submitted July 26, 1951.
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lism consisted of an initial split of the pentose into a 2-carbon and a 3-carbon fragment. The 3-carbon fragment has been identified as triose phosphate by coupling the bacterial system with crystalline triose phosphate dehydrogenase prepared from rabbit muscle. The 2-carbon fragment is believed to undergo a dismutation reaction resulting in the formation of ethylene glycol and glycolic acid. The splitting of pentose phosphate was stimulated by Fe^{++} , Co^{++} , Mg^{++} and cysteine. It was inhibited by Fe^{+++} . The optimum pH range for the catabolism of pentose was wide with an optimum at pH 8.2.

Pentose phosphate synthesis has been

accomplished by an enzymatic combination of triose phosphate and glycolaldehyde or glycolaldehyde phosphate, catalyzed by cell-free extracts of *E. coli* and *M. pyogenes* var. *aureus*.

Improved methods have been described for the preparation of glycolaldehyde phosphate and inosinic acid. The glycolaldehyde phosphate was prepared by periodic acid oxidation of α -glycerol phosphate and isolated as the barium salt by alcohol precipitation. Inosinic acid was prepared from horse muscle by an improved method which included a quantitative study of the optimum conditions for the isolation of the nucleotide.

SOME CALORIMETRIC STUDIES OF THE METALS AND CHLORIDES OF CERIUM AND NEODYMIUM¹

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The following thermal data have been measured for some of the compounds and metals of cerium and neodymium: (1) the heats of solution and dilution of the anhydrous chlorides in aqueous solution; (2) the changes in heat capacities of solution and dilution of the anhydrous chlorides in aqueous solution; (3) the heats of solution of the anhydrous chlorides and metals in aqueous hydrochloric acid; (4) the heats of solution of the hydrated chlorides in aqueous solution; (5) the heats of precipitation of the oxalates in aqueous oxalic acid solution; and (6) the heat capacity of neodymium metal in the temperature range of 0° to 250°C. In addition, the heats of solution and dilution of potassium chloride and oxalic acid hydrate in aqueous solution, and the heat capacity of tantalum metal from 0°C. to 425°C. have been measured.

From the data on the heats of solution and dilution, the following thermodynamic quantities have been determined: (1) the relative apparent molal and relative partial molal heat contents of solutions

of the chlorides of cerium and neodymium; (2) the relative apparent molal and relative partial molal heat capacities of solutions of the chlorides of cerium and neodymium; (3) the heats of formation of the anhydrous chlorides of cerium and neodymium; (4) the heats of hydration and of formation of hydrated chlorides of cerium and neodymium; (5) the heats of formation of the hydrated oxalates of cerium and neodymium; and (6) the heats of formation of the ions of cerium and neodymium. Revised values for the heat of solution at infinite dilution of potassium chloride and the heat of formation of oxalic acid hydrate have been presented. With the aid of data in the literature, the entropies, entropies of formation, and free energies of formation of the above chemical substances, as well as the standard electrode potentials of the metals of cerium and neodymium have been calculated.

The heats of solution and dilution were measured by the use of an isothermal calorimeter kept in a bath thermostatically controlled at $25.00 \pm 0.01^\circ\text{C}$; the temperature of the calorimeter was measured by the use of transposed-bridge thermometer to an accuracy of 30 micro-degrees. The heat capacities of tantalum and neodymium metals were measured by the use of ice calorimeters similar to those

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described by Ginnings and Carruccini³ and by Ginnings, Douglas, and Ball.⁴ The accuracy of the measurements of the heat of solution calorimeter and its contents and the accuracy of the measurements of all the heats of solution and dilution were within 0.1 per cent. The accuracy of the measurements of the heat capacities of solids by use of the ice calorimeters was about one per cent.

The heats of solution of anhydrous neodymium chloride were found to be greater than those of anhydrous cerium chloride; this phenomenon is mainly due to the formation of more stable dipole bonds between the neodymium ion and the surrounding water molecules since the lattice energies of the two anhydrous chlorides should be of the same order of magnitude. From these considerations and the fact that the ionic radius of the rare earths decreases with increasing atomic number, the heats of hydration of the rare earth ions should increase with the atomic number.

An extrapolation of the data on the heats of solution and dilution of the two chlorides to infinite dilution showed agreement with the simplified Debye-Hückel theory. For solutions more concentrated than 0.05 molal, the relative apparent molal and partial molal heat contents of cerium chloride were found to be greater than those of neodymium chloride. A tentative

explanation is that, in addition to the heat effects attributed to the difference in the parameter of closest approach of the ions, a second coordination number may become possible as the rare earth ion becomes larger with decreasing atomic number. Moreover, an equilibrium exists between the two hydrated ion-species: a shift in this equilibrium, as the concentration increases, is associated with an increase in the observed heat contents. Additional data will be required before any definite conclusions can be drawn.

The heats of solution of the anhydrous chlorides of cerium and of neodymium in hydrochloric acid were found to be less than they were in water. For solutions of the same concentration of electrolytes, the heats of solution of neodymium chloride were reduced more than those of cerium chloride. Further experimental evidence will be required to show if this behavior varies with ionic radius for the rare earths and whether it is due to association.

The measurements of thermal properties of cerium and neodymium and some of their compounds, presented in this thesis, are of importance in furnishing data which are useful in applying the laws of thermodynamics to these substances. The data are part of an extensive program for the accumulation of accurate data on the physicochemical properties of all the rare earth metals and salts in progress at the Ames Laboratory. Such data will furnish the information by means of which the present theories of solutions and solids can be examined in greater detail than has heretofore been possible.

- 3 Ginnings, D. C., and R. J. Carruccini, *J. Research Natl. Bur. Stds.*, **38**, 583-591 (1947).
- 4 Ginnings, D. C., T. B. Douglas, and A. F. Ball, *J. Research Natl. Bur. Stds.*, **45**, 23-33 (1950).

SOME STUDIES ON AROMATIC NITRATION¹

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In recent years, the mechanism of aromatic nitration has been the subject of numerous studies.³ Several anomalies, however, still exist, one of these being the *ortho-para* ratio obtained upon the nitra-

tion of the derivatives of benzene. The few theories advanced to account for *ortho-para* ratios are not sufficient to explain the observed experimental results. It was with the idea of attempting to elucidate these facts, that this work was undertaken. The problem is one of general interest since a better understanding of the factors involved in aromatic nitration will necessarily lead to a more complete understanding of substitution reactions in general.

The ultraviolet spectra of a number of

- 1 a. Chairman of Committee, George S. Hammond, Dept. of Chemistry.
- b. Doctoral Thesis No. 1203. Submitted July 31, 1951.
- 2 a. E.S., Case Institute of Technology, Cleveland, Ohio, 1943.
- b. Assistant, Industrial Science Research Institute, Institute for Atomic Research.
- 3 For an extensive review see: R. J. Gillespie and D. J. Millen, *Quart. Revs.*, **2**, 277 (1948).

different nitrohalobenzenes in solvents of widely different polarity have been studied. The spectra have been interpreted on the basis of the interaction of the compounds with the solvents and also on the basis of steric effects.

The ultraviolet spectrum of nitrobenzene in various compositions of sulfuric acid-

tric constant of the medium upon the activities of the nitronium ion and the transition state. The nitronium ion being much smaller than the transition state is affected to a much greater extent.

The isomer ratios obtained from the nitration of 2,5-dichloronitrobenzene and 2,5-dibromonitrobenzene have been studied

TABLE I
NITRATION OF 2,5-DICHLORONITROBENZENE

Temp.	Percentage Acid H ₂ SO ₄	Percentage Isomers			$\frac{M}{O}$	$\frac{O}{P}$
		<i>Ortho</i>	<i>Para</i>	<i>Meta</i>		
100°.....	96.2	21.4	27.7	50.8	2.4	0.77
100°.....	95.	24.5	25.8	49.6	2.0	0.95
100°.....	89.	29.0	24.1	46.8	1.6	1.2
100°.....	Fuming	14.5	32.5	53.0	3.7	0.45
140°.....	96.2	25.0	27.5	47.5	1.7	0.91
100°.....	Fuming HNO ₃ 20% HClO ₄	33.1	21.1	45.7	1.4	1.6
100°.....	96.2 KHSO ₄	24.2	27.3	48.4	2.0	0.89
100°.....	96.2 KClO ₄	25.8	26.4	47.8	1.9	0.98
140°.....	Fuming	11.4	34.8	53.8	4.7	0.33

water solutions has been studied in order to be better able to elucidate the species present in these solutions. Nitrobenzene is considered to be completely hydrogen bonded to sulfuric acid above concentrations of 90 per cent sulfuric acid. The fall in nitration rate in solutions above 90 per cent sulfuric acid is rationalized on the basis of the effect of the changing dielec-

by means of an infra-red analysis of the reaction mixtures. The results are summarized in Table I and Table II. These results are correlated on the basis of two effects operating concurrently, the effect of the solvent upon the polarizability of the nitro group and the effect of the dielectric constant of the medium upon the free energies of activation of the possible

TABLE II
NITRATION OF 2,5-DIBROMONITROBENZENE

Temp.	Percentage Acid H ₂ SO ₄	Percentage Isomers			$\frac{M}{O}$	$\frac{O}{P}$
		<i>Ortho</i>	<i>Para</i>	<i>Meta</i>		
100°.....	Fuming	2.9	43.1	53.9	18.6	0.07
100°.....	96.8	13.7	36.3	50.0	3.6	0.38
100°.....	90.	29.2	20.8	50.0	1.7	1.4
100°.....	Fuming HNO ₃ 20% HClO ₄	29.9	21.3	48.8	1.6	1.4
120°.....	96.8	19.6	29.4	51.0	2.6	0.67

transition states corresponding to the available positions for nitration. The differences between the results obtained in the nitration of dichloronitrobenzene and dibromonitrobenzene can be rationalized on the basis of the greater steric effects present in the dibromonitrobenzene molecule.

The most favorable case for *ortho* substitution would be the nitration of the unsolvated compound itself since the polarizability of the nitro group would be unhampered. The nitronium ion would be

attracted to the *ortho* position by the formal negative charge on the oxygen of the nitro group.

Generalizing from this study, it could be expected that all deactivating electro-meric substituents would have *ortho-para* ratios greater than unity if the polarizability of the substituent was not too greatly affected by the solvent. Thus, all of the deactivating electromeric substituents can be considered to be *ortho* directors in a limited sense.

ABSORPTION SPECTRA OF LEAVES¹

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It is well known that light is one of the major environmental factors which influence the growth and the behavior of plants. Physiologically, the light reflected and absorbed determine the over-all energy balance of the plant. Not all wavelengths are absorbed or reflected equally, however. The absorption spectra, in particular, are characteristic of both the physical and chemical structure of the plant. Because the leaves are the primary light-absorbing organ, leaf absorption spectra have been most fully investigated.

The present study was undertaken to provide data pertaining to several aspects of the more general problem. Absorption and reflection spectra were obtained for several species to determine the characteristics of the more typical types of leaves. Included were thick, heavily pigmented leaves and leaves with white, glaucous or tomentose surfaces, to determine the effect of these special morphological features. Because the absorption spectra of leaves are characteristic not only of the kinds of pigments present but also of their physical state, a study was made of the effect of different treatments which might be expected to influence the state of the pigments. To this end, comparisons were made between the spectra of leaves dipped in ether and in boiling water with those of untreated leaves and with methanol

extracts. The change in absorption and reflection spectra produced by infiltrating the air spaces of leaves with water was also determined. Finally, the influence of the nonpigmented part of the leaf structure, and of the plastid structure on absorption spectra were determined by comparing the spectra of chloroplast and disintegrated chloroplast suspensions with those of the fresh leaf.

Because of the physical structure of leaves, determinations of absorption spectra require the measurement of scattered light reflected by, and transmitted through, the leaves. The first part of the problem, therefore, consisted of assembling a suitable spectrophotometer. The one used here consisted of a projection lantern, quartz prism monochromator, integrating sphere, photomultiplier tube and a stabilized high voltage power supply. Tests showed that it possessed sufficient stability and accuracy for the intended purpose.

The leaf absorption and reflection spectra showed certain features common to all of the species. An absorption maximum was found at 680 $m\mu$, a minimum at 550 $m\mu$, and points of inflection suggestive of minor bands were found at about 600 and 640 $m\mu$. The reflection curves reached a maximum at 550 and a minimum in the vicinity of 680 $m\mu$. Curves representing the mean absorption and reflection for four species were obtained, and from these mean values of absorption and reflection for the entire region 400-700 $m\mu$ of 82 and 10 per cent respectively were calculated. Absorption in the three spectral regions 400-500, 500-600 and 600-700 $m\mu$ averaged 92, 71 and 84 per cent respectively. The thick leaf

1. a. Chairman of Committee, W. E. Loomis, Dept. of Botany and Plant Pathology.
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of *Ficus* showed a reduced reflection, an increased absorption and a broadening of the band in the red as compared with more typical leaves. The white, tomentose, lower surface of a white poplar leaf increased the reflection and decreased the absorption by 15 per cent when the light was incident upon the lower surface as contrasted with the data obtained when the light was incident upon the upper surface.

Dipping a leaf in boiling water was shown to cause a reduction in absorption and reflection and a shifting of the absorption spectrum by 5-10 $m\mu$ toward the blue. Spectra of leaves dipped in ether showed a slightly greater shift toward the blue and either an increase or a decrease in absorption throughout the region 500-660 $m\mu$, depending upon the length of treatment. In neither case were the spectra shifted to correspond with the spectra of the leaf extracts. Infiltrating the leaves with water resulted in no shift of the spectra but in a general reduction in both reflection and absorption.

Some data relative to the absorption spectrum of the pigment complex freed from interference by the leaf structure

were obtained by comparing the absorption spectra of leaves and leaf extracts with those of chloroplast and disintegrated chloroplast suspensions. These suspensions and extracts were so prepared that, when placed in a 1-cm. absorption cell, the quantity of pigment per unit cross-sectional area of light beam was the same as that obtained when using a sample of leaf tissue. The absorption curves for the suspensions agree as to position of the maxima and minima with those for the fresh leaf, but the maxima and minima are more sharply defined. The effect of progressively smaller particle size in reducing the multiple reflection and thereby the apparent absorption is also evident.

The data presented clearly show that the absorption spectra of leaves cannot be predicted from the spectra of their extracts. Furthermore, the absorption characteristics of the pigments while in the leaf and of the pigment complex are not predictable from the absorption spectra of either the fresh leaves or leaf extracts. The need is emphasized for more definite knowledge about the pigment complex if the results of investigations, such as the present one, are to be more accurately interpreted.

RESPONSE OF YOUNG DAIRY CALVES TO AUREOMYCIN FEEDING¹

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The present study, conducted in two separate experiments, was initiated to determine the effects of aureomycin supplementation on the growth and health of young dairy calves when fed and managed under practical conditions, and to ascertain whether the supplemental aureomycin produced differences in digestibility and in efficiency of utilization of various feed nutrients when calves were restricted to a reconstituted skimmilk diet.

In Trial I, 34 calves were divided into four groups and were fed, over a period

of 16 weeks, hay *ad libitum*, a concentrate limited to a maximum of 4 pounds per calf daily and a limited quantity of milk. Two groups received whole milk and two received a reconstituted skimmilk with the dry matter content adjusted to yield a product approximately calorically equivalent to the whole milk. Supplemented vitamins A and B were fed to the latter two groups. To one group in each dietary regime crystalline aureomycin hydrochloride, 80 mg. daily per calf was fed in the milk via nipple pail.

The antibiotic-supplemented calves had a mean daily gain of 1.46 pounds for the 16-week period as compared to 1.15 pounds for the non-supplemented calves, a difference that was statistically significant at the P_{.05} level. The Ayrshire, Guernsey and Jersey calves of the supplemented

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b. Doctoral Thesis No. 1256. Submitted March 13, 1952.
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groups showed an average increase (in weight gains) over the control calves of these breeds of 41 per cent as compared to a 12 per cent increase for the aureomycin-fed Holstein calves over their respective controls.

The aureomycin-fed calves consumed 21 per cent more hay and 11 per cent more concentrate than the control animals. Moreover, the ratio of calculated TDN consumption to body weight gain revealed that the supplemented calves utilized the feed consumed more efficiently than did the control animals. The supplemented calves required an average of 2.0 pounds of TDN per pound of gain as compared to 2.3 pounds for the control calves.

Type of milk had no significant effect on growth response of the calves, but incidence of scouring, which was comparatively low in all groups, was slightly higher among calves fed skimmilk. Although the mean number of days diarrhea was observed during the 16-week trial was lower for the aureomycin-fed calves than for the control animals, scouring was not entirely eliminated by aureomycin feeding.

The calves receiving aureomycin exhibited a sleek hair coat and a smooth appearance (fleshing) noted after about the third or fourth week of the trial.

In Experiment II, 4-day-old Holstein male calves were divided into two groups of five calves each and were restricted for an 8-week period to a diet of reconstituted skimmilk containing 20 per cent milk solids-not-fat, supplemented with vitamins A and D. The milk was fed at the rate of 10 pounds per day per 100 pounds body weight except that no calf was fed more than 12 pounds daily. At 60 days of age and continuing for a second 8-week period, hay and concentrates also were fed. Each calf in one group received 80 mg. daily of crystalline aureomycin hydrochloride fed in the milk via nipple pail.

The mean weight gains and the TDN

ingested per pound of weight gain for the first 8-week period were the same for both groups of calves. However, during the subsequent 8-week period, when hay and concentrates were being fed, the weight gains and the efficiency of feed utilization were greater for the antibiotic-fed calves. The average daily gain during the second 8-week period was 1.7 pounds for the supplemented calves and 1.4 pounds for the control animals as compared to 1.0 for both groups during the initial 8-weeks.

Three successive 24-hour samples of urine and feces were obtained from each calf at 2, 5 and at 8 weeks of age. Analyses of the urine for reducing sugars and nitrogen and of the feces for dry matter, reducing sugars, nitrogen, ether extract and ash revealed no differences attributable to aureomycin supplementation.

Once during each 3-day collection period and again at about 12 weeks of age, venous blood samples were taken at feeding time and at 2, 4, 6, 8 and 10 hours postprandially and were analyzed for reducing sugars. Although the mean blood reducing sugar levels rose slightly more rapidly and exhibited greater increases in samples from calves fed aureomycin than in those from the controls, the differences were not statistically significant. The sugars found in the blood, urine and feces were calculated as glucose since the presence of appreciable amounts of other sugars was not demonstrated by 2-dimensional paper chromatograms.

Under the conditions of this experiment, aureomycin supplementation stimulated the appetite of the calves causing them to consume more feed and resulted in a faster rate of gain in body weight and a more efficient utilization of feed. Furthermore, the supplemented calves exhibited smoother hair coats, more fleshing and less digestive upsets than the non-supplemented animals.

LENGTH OF GESTATION AMONG INBRED LINES OF SWINE¹

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Analysis of 2517 periods of gestation from 1682 sows among one Danish Land-race and twelve Poland China inbred lines of swine was made by fitting constants for line of dam, inbreeding of dam, inbreeding of litter, age of dam, birth weight of litter, season of farrow (spring or fall) and type of mating (inbred or crossline).

Genuine line differences were found to exist. Differences between lines accounted for thirteen per cent of the variance. The line means ranged from 115.9 to 118.5 days, with the mean of the entire group at 117.03 days and a standard deviation of 1.97 days.

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Environmental effects included in the study were age of sow, birth weight of the litter, season of farrow and inbreeding of dam. These effects were found to be real but small. Weight of the litter at birth accounted for three per cent of the variance and all together the five remaining effects accounted for three per cent of the variance.

The relation between birth weight of the litter and the length of gestation was negative. Litters weighing less than 10 pounds at birth were carried .9 of a day longer than the average, and litters weighing over 40 pounds at birth were carried .7 of a day less than the average.

Litters farrowed in the spring were carried .4 of a day longer than litters farrowed in the fall.

Repeatability for length of gestation was .26. Heritability of the length of gestation was .21 as estimated from the resemblance between full sibs in 400 full sib groups.

THE LIPASE OF *PSEUDOMONAS FRAGI*¹

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Pseudomonas fragi is widely distributed in nature and commonly is encountered in dairy products. This organism grows at low temperatures and is capable of producing an extra-cellular lipase which hydrolyzes the butterfat, leading to the development of objectionable flavors. The products of hydrolysis of butterfat are particularly important in butter, where the volatile free fatty acids cause the defect known as rancidity and the water-insoluble fatty acids are used as a measure of

the deterioration of either butter or the cream from which the butter was made. The lipase system apparently has not been studied previously independent of the growing cells.

This study was undertaken to gain a better understanding of the nature of the enzyme and the conditions under which it is produced. The growth medium after incubation, usually for three days at 15°C., was centrifuged at 4000 r.p.m. and the clear supernatant was used as a lipase preparation. Lipase activity was measured by the number of milliliters of 0.05 *N* methanolic potassium hydroxide required to neutralize the titratable acidity in an ethyl ether-petroleum ether extract obtained from 10 g. of the substrate after the enzyme has been allowed to react for 24 hours at 36°C.

- 1 a. Chairman of Committee, F. E. Nelson, Dept. of Dairy Industry.
b. Doctoral Thesis No. 1222. Submitted November 12, 1951.
- 2 a. B.S., Iowa State College, Ames, Iowa, 1948.
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in a ten per cent phosphate-buffered coconut oil emulsion at pH 7.2.

Sodium taurocholate was a good emulsifier in the lipase test substrate between pH 5.8 and pH 8.0. It showed some activation of lipase when used in 0.1 to 0.6 per cent concentrations, while sodium glycocholate was inhibitory in similar concentrations. Formaldehyde, which was used as a bacteriostatic agent, was slightly inhibitory to lipase action in concentrations above 0.036 per cent.

The relationship between lipase activity and either reaction time or lipase concentration deviated from a straight line function, indicating partial inactivation or inhibition of the enzyme. This deviation was more marked at 36 and 40° than at 32°C. That this deviation might be the result of some inactivation of the enzyme is suggested by the considerable loss of lipase activity which occurred in 24 hours at 36°C., whereas the loss was small at 15°C. and negligible at 3-5°C. In coconut oil emulsions, the loss in lipase activity at 36°C. was less marked than in peptone broth, presumably due to the protective action of the substrate. Maximum lipase activity in coconut oil emulsion during a reaction period of 24 hours was observed at 40°C.

Appreciable lipase activity remained after heating the enzyme preparation at 61.6 or 71.6°C. for 30 minutes. Complete inactivation of the enzyme required heating at 99°C. for 20 minutes. Considerable lipase activity usually was lost during the time required to bring the enzyme preparations up to the temperatures of 61.6, 71.6 and 99°C. The drop in lipase activity after the holding temperature had been reached occurred at a much slower rate than during the "coming up" period. A greater percentage of lipase was inactivated during the time required to bring the lipase preparation up to the temperature of 61.6°C. than in the corresponding interval at 71.6°C. Heat inactivation of the lipase in cream was less marked than in peptone broth, over 50 per cent of the lipase activity remaining after heating the cream at 71.5°C. for 30 minutes, as compared to less than 25 per cent in peptone broth.

The lipase of *Ps. fragi* was active between pH 6.0 and pH 8.7 with an optimum at pH 7.0 to 7.2, using phosphate-buffered ten per cent coconut oil emulsion at 36°C. for 24 hours. Lipase activity was somewhat higher with Clark's phosphate buffer than with McIlvaine's citrate-phosphate buffer.

There was some evidence of substrate preference by the lipase of *Ps. fragi*. Tri-caprylin was hydrolyzed to a greater extent than tributyrin, tricaproin, trilaurin, trimyristin and triolein. Coconut oil also was hydrolyzed at a more rapid rate than butterfat, olive oil, corn oil, soybean oil and cottonseed oil. This increased hydrolysis might be due to the higher content of tricaprylin in coconut oil.

Almost quantitative recovery of lipase was accomplished by salting out the enzyme by fully saturating the peptone broth containing the enzyme with ammonium sulfate at temperatures below 8°C. About half the lipase activity was recoverable in a fluffy material that appeared at the surface of the saturated lipase preparation immediately after solution of ammonium sulfate. The remainder of the activity was found in the precipitate that formed after standing at 5-8°C. for 16 to 18 hours.

Lipase production varied widely among the ten different strains of *Ps. fragi* studied. The optimum temperature for lipase production depended upon the length of incubation. With longer incubation periods, the organism produced more lipase at lower temperatures. Using an incubation period of three days, maximum lipase production was observed at 15°C. or lower, the exact optimum varying somewhat among strains. Little or no lipase was produced at 30°C. in three days, although the organisms grew well. There was a parallelism between count of organisms and lipase production at low temperatures, especially at incubation temperatures below 12°C. The optimum temperature for lipase production coincided with a common holding temperature employed for cream on the farm.

The optimum initial pH of the growth medium depends upon the nature of the fermentable substrate in the medium and the extent and direction of the shift in pH during incubation. In nutrient broth, two optima were evident, one at an initial pH of 6.5 and the other at about 7.5.

Ps. fragi produced considerably more lipase in 100 ml. of peptone broth when the medium was dispensed into flasks exposing a surface area of 114 cm.² than in test tubes giving a surface area of 9 cm.². This greater lipase production was associated with higher counts in the flasks.

Sodium chloride has been reported to suppress lipase production in butter. In the present study, there was no detectable lipase activity in 0.3 ml. of material from cultures grown on peptone broth contain-

ing four per cent sodium chloride. The effect of the salt in low concentrations apparently is manifest in lower lipase production due to lower counts, while at concentrations above two per cent lipase production declines more rapidly than the count.

Appreciable lipase was produced by *Ps. fragi* in chemically-defined media containing ammonium chloride as the only source of nitrogen and either glucose or lactate as source of carbon, whereas little or no lipase production occurred in a similar medium with sodium citrate forming the source of reduced carbon. Lipase production in glucose or citrate defined media was increased appreciably by supplementation with L-leucine alone. This increase was more marked when a combination of L-leucine, DL-isoleucine, and DL-valine was used as a supplement. The combination of these three amino acids yielded appreciable lipase when used as the sole source of nitrogen and reduced carbon, but L-leucine was the only one of the three which when used alone supported appreciable growth and lipase production.

Lipase production levels in Bacto-peptone, proteose-peptone, vitamin-free casamino acids and tryptone media were much higher than in chemically-defined media. Peptone was the ingredient in nutrient broth that was responsible for lipase production, since it supported higher lipase activity when used alone than in the presence of beef extract in nutrient broth.

Addition of tricaprylin to vitamin-free casamino acids medium resulted in more than three-fold increase in lipase production by *Ps. fragi*. This increase appeared to be due to caprylic acid, since that fatty acid caused marked stimulation of lipase production comparable to that obtained with the triglyceride, whereas glycerol had no effect. Lipase production in vitamin-free casamino acids medium was not increased appreciably when the medium was supplemented with tributyrin and tricaproin or their respective fatty acids, whereas tripalmitin, triolein or their respective fatty acids markedly inhibited lipase production even though the bacterial counts often were increased. Trimyristin inhibited lipase production while myristic acid showed appreciable stimulation. The effect of trilaurin was variable, whereas lauric acid inhibited lipase production and growth of organisms in the concentration tried. Vitamin-free casamino acids medium supplemented with tricaprins supported increased lipase production, but capric acid caused an increase in lipase

production somewhat greater than that obtained with caprylic acid. Stearic acid and butterfat showed a pronounced inhibitory effect on lipase production but did not affect the growth of the organism.

Growth and lipase production in cream were relatively poor. However, the low level of lipase in cream caused appreciable fat degradation during incubation and, after the cream was subjected to pasteurization at 71.5°C. for 30 minutes and churned, enough lipase was retained by the butter to cause appreciable fat hydrolysis during storage.

The growth of *S. lactis* in association with *Ps. fragi* lowered the pH of cream considerably and caused marked reduction in lipase production, although the plate count on *Ps. fragi* was practically unaffected.

Butter containing residual lipase exhibited appreciable fat degradation when held at -10°C. for 60 days, developing fairly strong rancidity even when the defect was not organoleptically detectable at the beginning of the holding period. Similar butter held at 36°C. for two days, 2 to 5°C. for 30 days and 21°C. for seven days showed extensive fat hydrolysis, peppery taste and pronounced rancidity.

The conditions under which cream is produced and held on the farm frequently are favorable for growth and lipase production by *Ps. fragi*, particularly in the case of sweet cream. The low holding temperatures permit the organism to grow to competitive advantage and the slightly acid reaction allows greater lipase production and activity than in a product where considerable acidity has been produced by other microbial types. The fat degradation products resulting from lipase activity in cream are mostly associated with the fat and thus tend to go predominantly into the butter obtained from rancid cream. As these studies have shown, the lipase of *Ps. fragi* is not inactivated completely by the common pasteurization procedures and much of the active enzyme is retained in the butter. This residual lipase thus can attack the butterfat during storage and merchandising, even when low holding temperatures are employed. Although pasteurization will destroy the organism, and thus prevent the production of more lipase, this treatment, as commonly used, apparently will not prevent some rancidity development in butter churned from cream in which considerable numbers of *Ps. fragi* had developed under conditions permitting good lipase development.

SECONDARY BUCKLING IN HOLLOW RECTANGULAR COLUMN SECTIONS OF STEEL PLATES¹

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An experimental investigation was made of the secondary buckling characteristics of plates in hollow, rectangular members under axial compression loads. Each member was fabricated under usual shop conditions from a single, hot-rolled, mild structural steel plate with a longitudinal welded joint along one side of the member. The thicknesses of the material varied from 0.075 to 0.270 inches. The width-thickness (b/t) ratios of the sides of the members varied from 25 to 80. The widths of the plates varied from 3 to 10 inches. The lengths of the members varied from 6 to 50 inches.

The objectives of this study were: (1) to determine the secondary buckling characteristics of this type of member; (2) to indicate a safe and reliable design procedure; (3) to indicate the probable degree of dependability with which model analysis may be used if both prototype and model are fabricated under usual shop methods.

To determine the initial shape of the unloaded plates and the load-deflections of the plates under various applied loads, a plate contour meter was especially designed and built. The load-deflection profiles of the plates were used to determine the critical buckling loads. Two SR-4 electrical-resistance strain gages were placed at each corner at mid-height of each member to determine the load distribution.

Test critical buckling loads were compared with the theoretical Bryan³ loads. A study was made of the relationship between the average measured unit strain at the corners of the member and the average applied load per unit area. A comparison was made of the test ultimate loads and

the ultimate loads predicted by Timoshenko's⁴ large deflection theory and by Von Karman's⁵ equivalent-width method. A study was also made of the load-deflection profiles and buckling patterns. Certain aspects of model analysis were also briefly discussed.

Some of the more important results and conclusions were:

(1) The secondary buckling strengths of the plate elements of the members tested were dependent on the width-thickness ratios of the plates, the degree of edge support along the unloaded edges of the plates, the properties of the materials, the initial irregularities in the plates and the degree of departure from the ordinarily-assumed idealized testing conditions.

(2) Elastic buckling failure for members of square cross section occurred in the b/t ratio range of 70 to 80 and probably occurred in the 60 to 70 range also.

(3) Inelastic buckling failure for members of square cross section occurred in the b/t ratio range of 24 to 50 and probably in the 50 to 60 range also.

(4) The Bryan formula with $k = 4.0$ may be used in the b/t ratio range of 70 to 80 for square cross sections if the overall width of the plate is used to compute the b/t ratio. For a b/t ratio less than 70, the proposed test curve for the buckling resistance of the members should be used. The equation of this curve is $\sigma = 5 b^2/t^3 - 1080 b/t + 71,000$ and is valid for b/t ratios of 20 to 80.

(5) For members of rectangular cross section with a long side-short side ratio of 0.6 for the cross section, the theoretical values were not reached in the range of b/t ratios tested. The proposed curve for buckling resistance of the test members should be used. The equation of this curve is $\sigma = 6.1 b^2/t^3 - 1025 b/t + 65,000$ and is valid for b/t ratios of 40 to 80.

(6) To arrive at allowable design plate

- 1 a. Chairman of Committee, Frank Kerekes, Dept. of Civil Engineering.
- b. Doctoral Thesis No. 1194. Submitted July 18, 1951.
- 2 a. B.S., Iowa State College, Ames, Iowa, 1943. M.E., Agricultural and Mechanical College of Texas, College Station, Texas, 1949.
- b. Assistant, Engineering Experiment Station.
- 3 Bryan, G. H. On the stability of a plate under thrusts in its own plane, with applications to the "buckling" of the sides of a ship. Proceedings of the London Mathematical Society. 22: 54-67. 1891.

- 4 Timoshenko, S. Theory of elastic stability. 1st ed. New York, McGraw-Hill. 1936. p. 395.
- 5 Von Karman, T., Sechler, E. E., and Donnell, L. H. The strength of thin plates in compression. ASME Transactions. 54: Apm 53-57. 1932.

loads for the type of members used in this investigation, it was considered more justifiable and reasonable to apply a reasonable safety factor to the test curve representing the buckling resistance of the members than to apply a safety factor to the Bryan curve.

(7) The stress-strain curve for a member was very helpful in evaluating the behavior of the member. The proportional limit of the curve indicated the average unit load at which the yield point was reached at one or more corners of the member or at which the critical buckling load had been passed.

(8) For all members which failed inelastically (b/t ratios from 24 to about 60), the proportional limits of the stress-strain curves for the members averaged 77 per cent of the ultimate loads for the members with a range of about ± 11 per cent of the average.

(9) For all members which failed elastically (b/t ratios from about 60 to 80), the proportional limits of the stress-strain curves for the members averaged 89 per cent of the ultimate loads with a range of about $\pm 7\frac{1}{2}$ per cent of the average.

(10) The computed theoretical ultimate buckling loads of the members of square cross section by the Timoshenko large deflection theory were higher than the test values for all members. For the members which failed elastically, the theoretical values were too high by from 3 to 24 per cent. For the members which failed inelastically, the theoretical values were much too high and would be unsafe to use.

(11) The predicted ultimate loads of the test members by the Von Karman equivalent-width method were higher than the test ultimate loads for all members when the theoretical value of $C = 1.9$ was used. For the members which failed elastically, the predicted values were from 10 to 25 per cent higher than the test values. For the members which failed inelastically, the predicted values were from 21 to 110 per cent too high.

(12) Safe predicted values of the ultimate buckling loads were obtained by the equivalent-width method when the experimentally-determined Sechler values of C were used. The predicted values were from 7 to 25 per cent lower than the

test values except for two members for which the predicted values were up to 6 per cent too high.

(13) The buckled wave patterns of the plates of the test members were entirely different from those predicted theoretically for ideal plates. Application of load on the plates tended to increase the magnitude of the initial irregularities.

(14) The shape and proportions of the cross sections had a significant effect on the behavior of the member. The different rates of buckling of the component plates of a member and the degree of edge support offered each plate by the adjacent plate elements had a substantial effect on the action of the member.

(15) The strength and general behavior of any plate in a member was substantially influenced by the strength and behavior of the other plates in the member. Instability in one plate of a member greatly accelerated instability in the remaining plates of the member.

(16) The welded joint along one side of each member gave additional buckling strength to that side by acting as a longitudinal stiffener.

(17) The fabrication process introduced initial irregularities in the plates of the members considerably larger than the initial irregularities in the rolled plates before fabrication.

(18) In the test members of Series A, which were nearly geometrically similar, there was a general trend for the ratio of maximum measured amplitude of initial irregularity to plate thickness to become larger with decreasing plate thickness.

(19) The results of this investigation indicated that the larger the length scale for a model, the greater the deviation in model predictability caused by the increasing amplitude-thickness ratio for decreasing thicknesses of plates; results of this and other investigations indicated that a length scale of 2 may be satisfactorily used for predicting secondary buckling characteristics of plates.

In addition, this investigation indicated a need for further study of secondary buckling in plate elements of members of the proportions and materials found in the practice of structural engineering.

SOME DERIVATIVES OF PHENOTHIAZINE¹

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Considerable interest is being shown in phenothiazine derivatives because of the discovery that certain 10-(dialkylamino-alkyl)phenothiazines are very active antihistaminic agents possessing a low degree of toxicity. Thus, the reactions of phenothiazine were investigated more fully with the view in mind that they might be employed in preparing other chemotherapeutically active derivatives of this heterocyclic compound.

The metalation product from the reaction of 10-(γ -diethylaminopropyl)phenothiazine and *n*-butyllithium was treated with benzophenone giving rise to an 8 per cent yield of 4-diphenylhydroxymethyl-10-(γ -diethylaminopropyl)phenothiazine (m.p. 140-140.5°). Under similar conditions, two products were isolated from the metalation of 10-[β -(1-pyrrolidyl)ethyl]phenothiazine; they were 4-diphenylhydroxymethyl-10-[β -(1-pyrrolidyl)ethyl]phenothiazine (m.p. 204-215°) and 4,6(?)bis(diphenylhydroxymethyl)-10-[β -(1-pyrrolidyl)ethyl]phenothiazine (m.p. 199-200°), formed in a 2.7 per cent and 12.3 per cent yield, respectively. Attempts to dimetallate phenothiazine and 10-ethylphenothiazine with *n*-butyllithium were unsuccessful; only monometallation resulted. The intermediate organometallic compound was tagged with benzophenone. In this instance, phenothiazine gave a 70 per cent yield of 1-diphenylhydroxymethylphenothiazine (m.p. 213-213.5°), and 10-ethylphenothiazine gave a 55 per cent yield of 4-diphenylhydroxymethyl-10-ethylphenothiazine (m.p. 180-181°).

An amphoteric substance which could not be purified was obtained from the metalation of 10-(γ -diethylaminopropyl)phenothiazine with *n*-butyllithium followed by carbonation. The crude product was cleaved with hydriodic acid to give *m*-carboxydiphenylamine, thereby showing that metalation had occurred in the 2- or

4-position of the phenothiazine nucleus. The 4-position was preferred by analogy with other metalation reactions involving 10-substituted phenothiazine derivatives. 10-Ethylphenothiazine-4-carboxylic acid was formed in a 53 per cent yield, subsequent to carbonation and acidification, by the action of *n*-butyllithium on 10-ethylphenothiazine-5-oxide at 0°. A similar reaction carried out at -20° resulted in the isolation of the acid (25 per cent yield) and 10-ethylphenothiazine (36 per cent yield).

Dimethyl sulfate reacted with phenothiazine in dioxane, in the presence of potassium carbonate, to give 10-methylphenothiazine (26 per cent yield). 10-Ethylphenothiazine resulted in almost quantitative yield by the reaction of ethyl bromide with 10-sodiophenothiazine (prepared from phenothiazine and sodamide) in liquid ammonia. The reaction was much less successful when carried out in refluxing benzene; the desired compound was obtained in a 36 per cent yield. 10-Benzylphenothiazine (m.p. 90-90.5°) was prepared in a 15.5 per cent yield by the reaction of benzyl chloride and 10-sodiophenothiazine in refluxing xylene. To show that rearrangement had not occurred in the latter reaction, 10-(*p*-tolyl)phenothiazine (m.p. 135-136°) and 10-(*o*-tolyl)phenothiazine (m.p. 101-101.5°) were prepared, in a 15 per cent and a 52 per cent yield, respectively, by the reaction of the appropriate aryl iodide and phenothiazine in the presence of potassium carbonate, copper bronze, xylene and nitrobenzene.

The attempts to condense *p*-bromo- or *p*-iodobenzene-sulfonamide, methyl 5-bromosalicylate, methyl 2-nitro-5-bromobenzoate and 2-nitro-5-bromobenzoic acid, respectively, with phenothiazine were unsuccessful.

Following is a list of 10-acylphenothiazines which were prepared by reacting the appropriate acyl chloride with phenothiazine, dissolved in dioxane, in the presence of sodium carbonate: the 10-acetyl (79 per cent yield), 10-chloroacetyl (45 per cent yield), 10-dichloroacetyl (m.p. 154-155°; 23 per cent yield) and 10-phenacetyl (m.p. 152-153°, 66 per cent yield) deriva-

- 1 a. Chairman of Committee, Henry Gilman, Dept. of Chemistry.
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tives. Dichloroacetic acid anhydride was also used to prepare the 10-dichloroacetyl derivative (32 per cent yield).

The action of 30 per cent hydrogen peroxide in refluxing ethanol oxidized phenothiazine, 10-acetylphenothiazine and 10-phenacetylphenothiazine to phenothiazine-5-oxide (96 per cent yield), 10-acetylphenothiazine-5-oxide (m.p. 169-170°, 83 per cent yield) and 10-phenacetylphenothiazine-5-oxide (m.p. 140-141°, 70 per cent yield), respectively. Under similar conditions, 10-ethylphenothiazine gave the monoxide (m.p. 162-163°, 62 per cent yield) and the dioxide (m.p. 161-163°, 15.5 per cent yield). Nitric acid in glacial acetic acid oxidized 10-acetyl-, 10-chloroacetyl- and 10-phenacetyl-phenothiazine to the corresponding sulfoxides in yields of 19 per cent, 86 per cent and 50 per cent, respectively. 10-Chloroacetylphenothiazine-5-oxide melted at 186-187°. The monoxide of the 10-dichloroacetyl derivative could not be prepared by this procedure.

In warm glacial acetic acid solutions, 30 per cent hydrogen peroxide oxidized the sulfur of the phenothiazine derivative to the sulfone. The following phenothiazine-5-dioxides were prepared in this fashion: 10-methyl (m.p. 220-221°, 44 per cent yield), 10-ethyl (m.p. 161-163°, 95 per cent

yield), 10-acetyl (m.p. 216-217°, 68 per cent yield), 10-chloroacetyl (m.p. 211°, 51 per cent yield), 10-dichloroacetyl (m.p. 211-212°, 70 per cent yield) and 10-phenacetyl (m.p. 215-216°, 48 per cent yield). By a similar procedure, 10-acetyl- (45 per cent yield) and 10-phenacetylphenothiazine-5-dioxide (77 per cent yield) were prepared from the appropriate monoxides.

The action of concentrated nitric and sulfuric acids on ethyl *m*-iodobenzoate gave an unidentified product (m.p. 196-196.5°) which contained the sulfone group but no nitrogen. Treatment of the compound with aqueous sodium hydroxide yielded ethanol and *m*-iodobenzoic acid. *m*-Iodobenzoic acid, under the same conditions, yielded a product (m.p. 246-247°) free of nitrogen and sulfur. Benzoic and *m*-hydroxybenzoic acid resulted from the action of nickel-aluminum alloy and aqueous sodium hydroxide on the product. *m*-Iodobenzoic and a hydroxyiodobenzoic acid were isolated following treatment of the product with aqueous sodium hydroxide.

The thesis also contains a survey of the chemistry of phenothiazine and a summary of the physiological properties of the 10-(dialkylaminoalkyl)phenothiazines.

NEW TECHNIQUE FOR MEASURING PHOTONUCLEAR CROSS SECTIONS AND ITS APPLICATION TO THE $\text{Cu}^{63}(\gamma, n)\text{Cu}^{62}$ AND $\text{C}^{12}(\gamma, n)\text{C}^{11}$ REACTIONS¹

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A new technique for the determination of photonuclear cross sections is described in detail. It was applied to the $\text{Cu}^{63}(\gamma, n)\text{Cu}^{62}$ and $\text{C}^{12}(\gamma, n)\text{C}^{11}$ reactions from thresholds up to 60 Mev. The results obtained are consistent and are in good agreement with results obtained by different methods (1, 2).

The synchrotron, which was used to induce the reactions, produces photons which have a continuous distribution in energy up to the kinetic energy of the electrons $E_0 - \mu$, where E_0 is the total electron energy and μ is the rest energy of the electron. Thus, $A(E_0 - \mu)$, the reaction rate for a photonuclear reaction, is proportional to the integral, from threshold T to $E_0 - \mu$, of the product of the cross section $\sigma(k)$ and the photon distribution $P(k, E_0 - \mu)$, where k represents the photon energy. Accordingly,

$$A(E_0 - \mu) = Na \int_T^{E_0 - \mu} \sigma(k) P(k, E_0 - \mu) dk, \quad (1)$$

where N is the number of atoms per square centimeter of sample material, and a is the area of the sample in square centimeters.

To solve Equation 1 for $\sigma(k)$ requires that $A(E_0 - \mu)$ and $P(k, E_0 - \mu)$ be known. The reaction rate may be obtained by measuring the radioactivity induced in the sample by the photonuclear process, and then converting the result to saturation activity. The photon distribution shape is believed to be known from theory (3) which has been verified experimentally at several values of $E_0 - \mu$ (4,5,6). To make use of the distribution shapes, there must be some means for adjusting the ordinates of the respective photon spectra to the values which are appropriate at the various electron energies at which the

synchrotron is operated while determining an activation curve. This leads to the necessity for monitoring the synchrotron beam.

Induced radioactivity provides a monitoring method if some information concerning the photonuclear cross section of the monitor is at hand. In the technique described here, one new way of using radioactivity to monitor the beam is employed in a way which appears to offer certain definite advantages.

The technique makes use of a mechanical device, called an oscillator, which slides a test sample and a similar monitor sample into and out of the beam. By means of a lead shield, one sample is shielded from the beam while the other is exposed to the beam. As the oscillator moves to and fro, the electron energy

value of the synchrotron is switched back and forth between two values. After many cycles of the oscillator have occurred, two radioactive samples are available for counting, each having been irradiated at different electron energies. Other runs are made under the same conditions of irradiation and counting for both samples. The electron energy value for the monitor sample is always kept the same; but the value for the test sample is changed from run to run. Since the monitor samples are always irradiated and counted under practically the same conditions from one run to another, any random or long period beam intensity changes will show up in the monitor sample activity. One of the monitor sample activities is arbitrarily selected as the one corresponding to a standard of beam intensity. Each test sample activity is then adjusted to the value it would have had if this standard of intensity had been present at the time

1 a. Chairman of Committee, L. Jackson Lasslett, Dept. of Physics.

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the sample was irradiated. These new activation results are directly proportional to the saturation activities that correspond to the standard of intensity, and when plotted they give a relative activation curve, $A(E_0 - \mu)$.

It would seem that the photon distribution required for the solution of Equation 1 is the integrated one of Bethe and Heitler (3), multiplied by the fraction of the total photon intensity which falls on the sample. This was not found to be true; therefore, it was necessary to determine experimentally the photon distribution which is applicable here. A relative activation curve for the $\text{Ag}^{107}(\gamma, n)\text{Ag}^{106}$ reaction was obtained with the oscillator.

within each of which an average cross section value was obtained. Since neither absolute counting nor absolute monitoring was performed, the cross section results are only relative. It would be possible, however, to make these results absolute if, for each reaction, one additional run were made at a certain value of $E_0 - \mu$ under conditions of absolute monitoring and counting. Since the relative cross section for the reaction is at hand, the absolute value of the cross section at this $E_0 - \mu$ could be determined. This value then could be applied to the relative cross section curve to convert it into an absolute one.

A somewhat extensive bibliography and

TABLE 1

Reaction	Threshold	Energy at Peak Cross Section	Width of Half Maximum	Reference
	Mev	Mev	Mev	
$\text{Cu}^{63}(\gamma, n)\text{Cu}^{62}$	10.9	17.5	5.7	a
	10.9	17.5	6.0	b
	10.6	17.0	6.5	c
$\text{C}^{12}(\gamma, n)\text{C}^{11}$	18.7	22.4	4.1	d
	17.5	20	3.5	c

^a Reference (1)

^b Reference (2)

^c Results of this paper.

^d Reference (8)

Since the general shape of the cross section for this reaction is known (1), it was possible to adjust the ordinates of the respective photon spectra to the proper values for use in Equation 1.

The discrepancy between the theoretical and the experimental adjusted photon distributions was large at the lower energies. This is attributed partly to the disagreement at lower energies between the theoretical (7) and the experimental bremsstrahlung intensity-angle distributions obtained here. In addition, such phenomena as the loss of electrons in the orbit and multiple traversals of the target by the electrons may cause a part of the disagreement.

Activation curves for the $\text{Cu}^{63}(\gamma, n)\text{Cu}^{62}$ and $\text{C}^{12}(\gamma, n)\text{C}^{11}$ reactions were obtained and then were used to solve Equation 1 for the respective cross sections. Table 1 shows a comparison of the cross section results obtained here with the results of other workers who used a different method. The analysis was made numerically by replacing the integral with a summation over photon energy intervals of 1 Mev in width,

review of the work previously done in the photonuclear field is included in the thesis.

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EVALUATION BY GRADUATES OF THE PROGRAM OF AGRICULTURAL ENGINEERING AT THE IOWA STATE COLLEGE¹

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Agricultural engineering as a distinct curriculum in American colleges and universities is of comparatively recent origin. Iowa State College, one of the first to inaugurate such a program, graduated its first student from agricultural engineering in 1910. Since that time there have been 604 students who have either graduated from this curriculum or have received an advanced degree in agricultural engineering. The number of graduates has varied widely throughout the 41-year period with the largest number, thirty-eight, graduating during 1950.

The trend in the number of graduates shows clearly the small number of graduates during the depression and during the periods of World War I and World War II. In general the number of graduates in agricultural engineering has followed the trend in number of graduates in the divisions of agriculture and engineering. The trend has been upward during the 41-year period with the rate of increase somewhat smaller than in other areas of engineering and somewhat larger than that prevailing in agriculture at Iowa State College.

The purpose of this investigation was to obtain from graduates their employment status, past and present, their major interest while in school, and to secure an evaluation of selected courses in the agricultural engineering curriculum. Questionnaires were mailed to individuals who had received the Bachelor of Science degree, or advanced degrees, in agricultural engineering from the Iowa State College prior to September 1, 1950. In all, 534 questionnaires were mailed from which there were 465 returns available for use in this study. Of this number 227 had graduated since 1940. This study, therefore, reflects the employment, major interest while in school, and opinions of the

recent graduates more than it does of those who graduated during the first thirty years the program was in operation.

When the graduates were classified according to the area of present employment, education ranked first as an occupational outlet for graduates of this curriculum with about one in every four graduates so employed. Of those whose present work was in education the large majority were teaching although seventeen were in research positions and ten were in extension work. Twenty were teaching some type of vocational education at the secondary school level.

When classification of graduates was made on the basis of major interest while in school, farm power accounted for the majority of majors, followed in order by farm structures, soil and water conservation and rural electrification, with but thirteen in the last classification. The area of employment, in general, seemed to follow the major interest in school. There were, however, so many exceptions to this rule that too great a curriculum differentiation in the program of education for these majors appears to be doubtful.

In addition to the classification on present employment the graduates were classified according to their first employment after graduation. In general, the first employment did not differ greatly from the present employment, except that it was noticed that the U. S. Department of Agriculture had more employees among these graduates than would be expected from the first employment after graduation. It was also noted that education was more often the first employment of those who had graduate degrees and those who held professional degrees than it was among other graduates in general.

The 465 graduates included in this study were polled concerning the amount of emphasis that should be placed upon certain selected courses which are of particular interest to those responsible for

- 1 a. Chairman of Committee, James E. Wert, Dept. of Vocational Education.
b. Doctoral Thesis No. 1213. Submitted August 28, 1951.
- 2 a. B.S., Iowa State College, Ames, Iowa, 1948.
M.S., *ibid.*, 1949.

the curriculum in agricultural engineering.

Three areas in productive agriculture—livestock problems, crop production, and animal feeding—were reported to have received about the right amount of emphasis by four out of five of all the graduates. The number who felt the emphasis was too great was about equal to the number who felt the emphasis was too little.

The four selected areas in engineering studied were: machine shop, engineering contracts, engineering valuations, and labor relations. About three out of every four graduates reported that the emphasis was about right in respect to machine shop, engineering contracts, and engineering valuations, whereas only one-half of the graduates believed that the emphasis was about right on labor relations. Of those who disagreed with the prevailing emphasis, more expressed the opinion that too little emphasis had been placed upon these four areas than too much. This was particularly true with regard to labor relations.

The five general areas of speech, journalism, differential equations, social studies, and economics were singled out for evaluation. The responses of graduates indicated that, at the time of their graduation, the emphasis upon speech, journalism, social studies, and economics was much too little. The emphasis upon differential equations reported by the graduates, no doubt, reflects the contact which the student had with this course. This contact has not been constant throughout the 41-year period but has been on occasions both elective and required. About seven out of every ten students felt the emphasis upon this subject was about right with dissenting opinion being split fifty-fifty between too much and too little emphasis. It was noticed that greater emphasis was sug-

gested by those students who graduated during the later portion of the 41-year period.

The desired emphasis upon six selected areas of agricultural engineering was evaluated by graduates. These areas were: wood construction, agricultural machines, agricultural engineering application, farm electrification, seminar (junior), and seminar (senior). Emphasis placed upon these courses, in general, was rated as about right by three out of every four graduates. Those not agreeing with this opinion had a tendency to indicate too little emphasis rather than too much.

It was of particular interest to note that in the evaluation of course emphasis, individuals who held graduate degrees in agricultural engineering had a tendency to report emphasis prevailing at the time of graduation to be about right more often than did others included in this study.

Of the 465 graduates there were forty-two individuals who were classified as holding professional degrees. In this number were classified all individuals who were department heads in various institutions and included seven who did not hold a professional degree. With the exception of two areas in productive agriculture the prevailing emphasis on all course areas here studied was more acceptable to members of this group than it was to other graduates.

The analysis of opinions of graduates indicates that throughout the 41-year period the constant revision of the curriculum which has taken place has tended to meet with the approval of those who have graduated in agricultural engineering. This constant revision which has taken place in the past suggests that curriculum content be subject to searching criticism in the future in order to meet the needed changes in the education of agricultural engineering students.

ECONOMICS OF FEED UTILIZATION

WITH SPECIAL EMPHASIS ON RISK AND UNCERTAINTY¹

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Farmers, and others interested in agricultural programs and policies, are concerned with the question of what is the most profitable forage acreage to produce. The most profitable forage acreage for any individual farmer is dependent on (a) the relationship of forage to grain in crop production and (b) the relationship between forage and grain in livestock feeding. This investigation focuses on the relationship between forage and grain and the problems involved in forage utilization through livestock feeding.

The specific objectives of the study are: (a) to indicate some of the alternative possibilities for increasing forage consumption by livestock, (b) to evaluate alternative feed utilization systems with respect to potential returns and variability of returns, and (c) to suggest criteria for determining the optimum forage-grain feed combinations in feeding livestock for individual farmers in different situations, with special emphasis on the basis for choice in a setting of uncertain market expectations.

In a static setting the criterion of choice between alternative forage-grain feed combinations is that the marginal rates of substitution between forage and grain equal the inverse of their price ratios; or, where feeds produced on a farm are used entirely for livestock production, the least cost combination is that which equates the marginal rate of substitution of forage

minishing marginal rate of substitution between forage and grain in livestock production. The following substitution relationships between forage and grain have been found for various classes of livestock:

a. Dairy cows producing 8500 pounds of 4 per cent fat corrected milk were found to substitute forage and grain according to the following production contour:

$$X_2 = \frac{8500^{2.5}}{3.56X_1}$$

where X_1 is the pounds of forage fed and X_2 is the pounds of grain fed per cow to achieve an annual production of 8500 pounds of milk.

b. Good to choice feeder steers fed to a good to choice finish were found to produce one hundred pounds of gain with various combinations of forage and grain indicated by the following iso-quant:

$$X_2 = 1111.15 - .4219X_1 + .0000686 X_1^2.$$

c. The product contour for one hundred pounds of pork production was estimated to be:

$$X_2 = 327.5 - .5113X_1 + .00423X_1^2.$$

d. The product contour for production of one hundred pounds of prime or choice lamb on feeder lambs was estimated as:

$$X_2 = \frac{2.3118 - .0037X_1 - [(2.3118 - .0037X_1)^2 .021175X_1 - .000031X_1^2 - 5.4267]^{\frac{1}{2}}}{.014792}$$

for grain in livestock feeding with the marginal rate of substitution of the two feeds in crop production.

Previous empirical research, as well as production economic logic, indicates a di-

The least cost feed combination is easily found by equating the inverse ratio of forage prices to grain prices with the tangent to each of the above iso-quant.

The above analysis fails to take into account the time variable. As forage is substituted for grain the length of the feeding period required to obtain a given livestock output may be lengthened. In extending the analysis to include the effect of timing of production, costs and returns from several discrete livestock feeding

- 1 a. Chairman of Committee, Earl O. Heady, Dept. of Economics and Sociology.
- b. Doctoral Thesis No. 1226. Submitted November 29, 1951.
- 2 a. B.S., University of Minnesota, Minneapolis, Minn., 1946.
- b. M.S., *ibid.*, 1947.
- b. Associate, Agricultural Experiment Station.

systems were derived by budgeting technique and compared.

Costs and returns for each of thirty-two years (1917-1948) were estimated for (a) four different feed combinations for dairy cows, (b) five systems of handling feeder cattle, and (c) six feed combinations for hogs. All systems are representative of feeding systems which are either common in the corn belt or offer possibilities for forage utilization under corn belt conditions.

In order to simplify comparisons between classes of livestock, returns were measured in terms of returns per \$100 of costs. Computations were made on the basis of (a) returns per \$100 all costs, (b) returns per \$100 feed and labor costs, and (c) returns per \$100 feed costs. Comparisons on the basis of feed and labor costs only are applicable in the many situations in which buildings and equipment are provided at no cost to the farm operator. Comparisons on the basis of returns per \$100 of feed costs only are appropriate where labor has no alternative profitable employment opportunities.

In choosing between alternative feeding systems it is assumed that livestock producers are guided by (a) their expectations regarding the probability distribution of future returns from each system and (b) their attitudes toward risk taking. While expectations regarding uncertain events must be subjectively determined, it is assumed here that various characteristics of the historical frequency distributions of returns from alternative ventures are helpful in ordering the relative attractiveness of the alternatives.

First, alternative plans are compared on the bases of mean returns over the thirty-two year period and the standard deviation of returns. Generally, the higher the mean

returns for a feeding system, the higher the variability of returns. Where this is true no unique "best" system can be determined; the system appearing most attractive to a particular individual depends on the intensity of his aversion to risk taking (i.e. the nature of his indifference map between standard deviation of returns and mean returns). In general, rational individuals will prefer a plan with a low variability (standard deviation) to a rival plan offering the same mean returns but with greater variability. But the extent to which individuals are willing to sacrifice mean returns (or total returns over time) in order to secure less variability of returns is different for different individuals, depending on such things as previous experience, educational background, financial position, and personality traits.

An alternative criterion of choice between rival feeding systems is the maximum loss relative to mean returns associated with the alternatives. Maximum loss is defined as the level of net loss given by the mean return minus two standard deviations. Again, no unique solutions are found unless a single feeding system has higher mean returns as well as a lower maximum loss associated with it.

A third criterion of choice is the maximum loss relative to the maximum gain associated with alternative plans, where maximum gain is defined as the level of returns two standard deviations above the mean.

The employment of the three criteria of selection, while it does not lead to determination of unique best feeding systems, narrows down the number of systems which might be optimum. The best choice for any one individual can be determined only as the nature of his risk preference is known.

PURIFICATION AND PROPERTIES OF BACTERIAL PYRIMIDINE NUCLEOSIDASE¹

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The reactions of purine nucleoside metabolism have long been studied and are quite well known. With the exception of one study, the metabolism of pyrimidine nucleosides had not been considered until quite recently. It was presumed that the dissimilation of pyrimidine nucleosides was similar to that of the purine nucleosides. This assumption is now known to be correct; pyrimidine nucleosides are metabolized in a fashion similar to that of the purine nucleosides.

Whole cells of *Escherichia coli*, *Aerobacter aerogenes* and *Micrococcus lysodeikticus* contain a nucleosidase that cleaves ribose from the nucleoside molecule. The free pyrimidine base accumulates in the reaction mixture and may be determined by spectrophotometric methods or isolated. The pyrimidine base is remarkably resistant to structural changes and alteration by enzymes. Only such appendages as amino and hydroxyl groups undergo change. Ribose does not accumulate in the reaction mixture, but disappears rapidly. Experiments with the Warburg respirometer indicate that ribose is oxidized immediately upon liberation to carbon dioxide and water. The exact nature of this process, however, still remains obscure.

The Mejbaum pentose test cannot be used for the determination of pyrimidine nucleosides. They are refractory to the conditions of hydrolysis of the test; even the most reactive of the compounds, uridine, shows but ten per cent of the response expected. By increasing the acidity and by extension of the heating period, the method can be modified so that the pyrimidine nucleosides will show increased response. This modified procedure was used to determine the amount of pyrimidine nucleoside remaining in the incubation mixtures.

Pyrimidine nucleoside phosphorylase was isolated from cell-free extracts prepared by subjecting cells of *Escherichia coli* to sonic disintegration. The enzyme was brought to a high degree of purity by fractional precipitation with ammonium sulfate and by adsorption on and elution from alumina C-gamma. The purified enzyme shows a six hundredfold increase in activity over that of the cell-free extract from which it was prepared.

As is its purine counterpart, pyrimidine nucleoside phosphorylase is a phosphorolytic enzyme. Inorganic phosphate is necessary for action of the enzyme; minimal amounts of nucleoside are cleaved when phosphate is removed from the system. That the enzyme is phosphorolytic is also indicated by the fact that ribose-1-phosphate is accumulated as a result of its action upon nucleosides. The presence of ribose-1-phosphate was determined by analytical methods. This was substantiated by isolation of ribose-1-phosphate as the barium salt.

Pyrimidine nucleoside phosphorylase was found to be highly specific. It is inactive against purine nucleosides. It does not attack cytidine, which indicates that cytidine must first be deaminated to uridine before nucleosidase activity can take place. It will not split thymine desoxyriboside. This should not be construed to indicate that the enzyme is specific for ribose nucleosides, since in all other cases studied so far nucleosidases show no specificity for either ribose or desoxyribose nucleosides. Uridine desoxyriboside, which is not a naturally occurring nucleoside and thus unavailable, would undoubtedly be split by the enzyme. It does indicate that the enzyme is inactive against thymine derivatives. Cytosine, thymine, and orotic acid do not react with ribose-1-phosphate in the presence of the enzyme, thus these compounds are not members of the reaction. Recently the riboside of orotic acid was isolated and characterized; this work demonstrates that the nucleosidase catalyzing the interconversion of orotic acid and its riboside is an enzyme

¹ a. Chairman of Committee, F. Schlenk, Dept. of Bacteriology.

b. Doctoral Thesis No. 1239. Submitted December 13, 1951.

² a. B.S., Nebraska State Teachers College, Wayne, Neb., 1943.

b. Assistant, Agricultural Experiment Station, Institute for Atomic Research.

separate and distinct from pyrimidine nucleoside phosphorylase.

Uridine was synthesized by the enzyme. Uracil when incubated with ribose-1-phosphate in the presence of pyrimidine nucleoside phosphorylase was converted

to uridine. The equilibrium between uridine splitting and synthesis in the presence of reduced amounts of inorganic phosphate was found to be sixty per cent in favor of synthesis and but forty per cent in favor of splitting.

POTENTIAL UTILITY OF THE MINNESOTA PERSONALITY SCALE IN COUNSELING HOME ECONOMICS STUDENTS AT IOWA STATE COLLEGE¹

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The present investigation was undertaken for the purpose of determining the usefulness of the Minnesota Personality Scale for the counseling of Home Economics students at the Iowa State College.

The criteria of the usefulness of the Personality Scale were in two principal areas. The first was that of academic achievement, and the second was a group of social-educational factors. The relationships of the Personality Scale to academic achievement were studied from the standpoint of survival-attrition and achievement as shown by grade-point average. The social-educational factors considered in the investigation were as follows: size of home community, type of college housing, selection of curriculum, visits to the college hospital, marriage plans, attitude toward experience at the Iowa State College, and state residence.

The subjects were 344 freshman women enrolled in the Division of Home Economics during the fall quarter of 1947. The study of survival-attrition and of first-quarter grade-point average was made with these subjects. Ninety-one of this original group were retested and studied after an interval of three and one-half years. The analysis of terminal grade-point average and of the social-educational factors was made with this group of 91 subjects.

The Minnesota Personality Scale has five sub-scales: Morale, Social Adjustment, Family Relations, Emotionality, and

Economic Conservatism. The scores of the Iowa State College subjects on the five sub-scales were found to be comparable to the scores of the norm group of the scale. The reliability coefficients were substantially the same as those reported by the authors. During the interval of three and one-half years the retested group were found to increase significantly in the direction of better adjustment on the Personality Scale.

The survival-attrition problem was treated statistically by the use of the discriminant function. There were four different groupings of subjects for whom discrimination on the basis of Personality Scale scores was attempted. They were the following: survival vs. total attrition; attrition-satisfactory-achievement vs. attrition-unsatisfactory-achievement; survival vs. attrition-satisfactory-achievement; and attrition-satisfactory-achievement plus survival vs. attrition-unsatisfactory achievement. The study of grade-point average and of the sub-scales of the Personality Scale required employment of correlation and linear regression. The results indicated no important relationships between any of the sub-scales of the Minnesota Personality Scale and academic achievement. However, the group which withdrew from college with satisfactory achievement was found to be lower on the Morale sub-scale.

The sub-scale scores of the 91 retested subjects were studied in relation to the social-educational factors by the technique of the analysis of variance. When the subjects were stratified according to one of the factors, the technique of covariance was employed. A number of significant relationships of the sub-scale scores to the classifications according to the social-

- 1 a. Chairman of Committee, James E. Wert, Dept. of Vocational Education.
b. Doctoral Thesis No. 1277. Submitted June 3, 1952.
- 2 a. B.S., State Teachers College, Salem, Massachusetts, 1945.
M.S., Harvard University, Cambridge, Mass., 1946.

educational factors were found. Sorority women, individuals from the larger home communities, and individuals from outside of the state of Iowa were found to have higher Social Adjustment scores. Poorer Social Adjustment scores were found for the group of subjects who visited the college hospital more often than average. A significantly greater increase in Family Relations score was found for the group of subjects enrolled in social-artistic Home Economics curricula. Higher Social Adjustment and Family Relations scores were found for those subjects who showed a generally better attitude toward their experience at the Iowa State College. Those subjects who planned to be married within a year of graduation had higher Economic Conservatism scores. It was also noted that the Morale scores of individuals from small home communities were lower than

the scores of those subjects from the larger communities.

In general the changes in sub-scale scores over the interval of three and one-half years were in the direction of greater homogeneity. Those subjects with initially high scores remained high while those with initially low scores increased in the direction of better adjustment.

The Social Adjustment sub-scale appeared to be most highly related to the variables studied. The Emotionality sub-scale showed no relationship to the variables studied.

The general results of the investigation appear to indicate no useful relations between the scores on the Minnesota Personality Scale and academic achievement, but significant relationships between the Personality Scale on the social-educational factors studied were found.

STATE OF AGGREGATION OF AMYLOSE IN AQUEOUS SOLUTIONS AND ITS RELATIONSHIP TO IODINE COMPLEX FORMATION¹

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The influence of temperature on the amylose-iodine complex was studied by determining the wave length of maximum absorption of amyloses at various temperatures. A decrease in the maximum wave length of from 30 to 40 μ is found to occur between room temperature and 40°. The change is temperature irreversible since upon cooling an over-all decrease of about 20 μ is found for the complex.

The treatment of amylose with KOH for several days decreases the wave length of maximum absorption from 20 to 30 μ ; regeneration of the amylose does not increase the maximum wave length.

Amyloses which are allowed to stand in N. KOH show a progressive decrease in iodine binding affinity with time. Upon regeneration the binding affinity is partially restored to the value obtained for samples dispersed for only a few minutes in N. KOH. A similar decrease is observed with amyloses which are kept in KOH

under nitrogen, thus indicating that oxidative degradation is not responsible for the change.

Fresh amylose samples prepared by regeneration are found to possess a greater binding affinity than those which have been aged. The complexing agent used in regeneration apparently influences the binding affinity. Samples pretreated with iodine show very high binding affinities after regeneration. A still higher binding affinity may be obtained from the back-titration of an amylose-iodine complex with sodium thiosulfate.

The iodine binding affinity and time required for retrogradation are found to be greatly affected by the pH at which amylose solutions are allowed to stand. Amylose solutions apparently are stabilized at pH values below 5 and may be kept for several days in the unretrograded state. Solutions at a neutral pH show a strong tendency to retrograde and also experience a large decrease in iodine binding affinity. The decrease in binding affinity is only partially due to the loss of soluble amylose from retrogradation. The behavior of amylose at a pH of 9 is intermediate between that at 4 and at 7.

- 1 a. Chairman of Committee, Joseph F. Foster, Dept. of Chemistry.
b. Doctoral Thesis No. 1223. Submitted November 14, 1951.
- 2 a. A.B., Western State College of Colorado, Gunnison, Colorado, 1944.
b. Graduate Assistant, Agricultural Experiment Station.

Turbidity measurements as a function of time of standing were made on amylose solutions adjusted to various pH values. Solutions at a neutral pH and high initial turbidities experience a large turbidity drop. This drop is apparently necessary for retrogradation to occur with solutions of high initial turbidities. The initial turbidity is generally stabilized at a pH of 4. The behavior at a pH of 9 is unpredictable. Iodine pretreatment was found to reduce the ability of amylose to retrograde at the neutral pH.

Turbidity measurements as a function of time in KOH were made on solutions of amylose. With solutions of high initial turbidity, a large decrease with time is observed. With amylose preparations which show a relatively low initial turbidity and retrograde at the neutral pH without experiencing a turbidity drop, a negligible drop is observed in KOH. The turbidity behavior is not changed appreciably by storing the solution in KOH under nitrogen.

Amylose solutions of low initial turbidities may retrograde at the neutral pH without experiencing a turbidity drop. However, if solutions of high initial turbidity are allowed to undergo a turbidity drop at the neutral pH and then the pH is adjusted to 4, retrogradation will occur. Solutions of amylose which show a low initial turbidity will also retrograde at a pH of 4.

The apparent molecular weights were determined on various amyloses by the light scattering method. Particle weights were determined initially and during the turbidity drop. The apparent molecular

weight is found to decrease as the turbidity drops. This behavior definitely establishes the presence of aggregates. The particle weight found at the turbidity minimum does not represent a minimum molecular weight. When amylose solutions are allowed to retrograde thoroughly, much lower particle weights are found. These weights are obtained after dispersing the retrograded material in one-half N. KOH. The apparent molecular weight of a typical corn amylose preparation was decreased from an initial value of 900,000 to 80,000 by this procedure.

The change in particle weight was determined on amylose in N. KOH under nitrogen. The rate of disaggregation is found to be initially slow but increases upon standing. After ten to fifteen days a constant particle weight is obtained. This value corresponds to that found at the turbidity minimum prior to retrogradation.

A correlation of apparent molecular weight, binding affinity and wave length of maximum absorption before and after retrogradation was made. A decrease in particle weight upon aging at the neutral pH causes a corresponding decrease in both the binding affinity and wave length of maximum absorption.

The results of these experiments have been interpreted in terms of the helical theory. The aggregates responsible for high molecular weights, high binding affinities and high wave length of maximum absorption are believed to be present in the native starch granule and remain at least partially intact during the dispersion of starch.

CHARACTERIZATION OF THE SOIL GLOBIFORME BACTERIA¹

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Although it has been widely recognized that the predominant bacteria in soil are small, slow-growing, pleomorphic organ-

isms, the function of these globiforme bacteria in the soil remains obscure. The morphology and physiology of this group have remained poorly defined, and there is little agreement on the characteristics that may be used for their generic or specific identification. Strong criticism of the trend to include saprophytic soil bacteria in the genus *Corynebacterium* has been expressed, and two separate proposals

- 1 a. Chairman of Committee, Francis E. Clark, Dept. of Agronomy.
b. Doctoral Thesis No. 1214. Submitted September 21, 1951.
- 2 a. B.S., Tennessee Polytechnic Institute, Cookeville, Tenn., 1937.
M.S., University of Tennessee, Knoxville, Tenn., 1938.

recently have been advanced for new generic designation. The genera *Arthrobacter* and *Jensenia* have been proposed. The validity of these proposals has not been fully examined, nor have the relationships of certain phytopathogenic and cellulolytic corynebacteria and of the animal diphtheroids to the soil globiforme bacteria been satisfactorily defined. The present investigation has undertaken such definition.

By direct microscopy with the light microscope, motility was noted for 10 of 26 cultures of soil globiforme bacteria, and cell branching, for all of them. Examination of cells in micro-colonies on thin agar films showed that *Jensenia canicruria* formed a distinct early mycelium. The soil globiforme, animal diphtheroid, cellulolytic, and phytopathogenic bacteria, and microbacteria examined failed to show noteworthy differences in cell size or shape, or in their micro-colonies. Fragmentation within micro-colonies was sufficiently rapid to prevent formation of an early open mycelium.

Observations made on cell smears stained by a tannic acid-crystal violet method failed to confirm recent claims that the soil globiforme bacteria possess simple cells, while the true corynebacteria possess compound cells. Cross-walled or compound cells were demonstrated in *Jensenia canicruria* as well as in *Arthrobacter globiforme*. *Jensenia* was found dissimilar, physiologically and in early mycelium formation, from the majority of named cultures designated as representative of the soil globiforme bacteria. It was concluded that *Jensenia* is not in synonymy with *Arthrobacter*, but that it very probably is in synonymy with *Nocardia*.

Except for *Jensenia*, the soil corynebacteria isolated by widely scattered workers were found to comprise a homogeneous group. This group was distinguished from corynebacteria of animal origin by its greater proteolytic activity, its ability generally to grow on protein-free media, and

its inability to produce acidity in dextrose nutrient broth. In view of these and other differences, it does not appear advisable to include the soil globiforme bacteria in the genus whose type is *Corynebacterium diphtheriae*. It was concluded that *Arthrobacter* constitutes a valid generic designation for the soil globiforme bacteria.

Arthrobacter cultures were compared to cultures of *Cellulomonas*, phytopathogenic corynebacteria, animal diphtheroids, and microbacteria in numerous cultural and physiological tests. All cultures were uniformly negative with respect to ammonia, indol, and acetylmethylcarbinol production and hydrolysis of sodium hippurate; all were uniformly positive for catalase production. Some differences were encountered in gelatinolysis, urea and uric acid hydrolysis, nitrate reduction, action on various organic carbon compounds, and in character of growth on diverse media. Carbohydrate fermentation responses were of no value in group or in species differentiation.

Contrary to its type description, *Arthrobacter simplicium* was found to show diastatic action on starch-agar plates. The recognition of *A. simplicium* as a species of *Arthrobacter* that fails to attack starch does not appear to be justified. Both *A. aurescens* and *A. helvolum* produced deep yellow pigmentation on nutrient agar and on potato, and both produced hydrolysis of uric acid. *A. aurescens* was urease negative, and *A. helvolum*, urease positive. *A. globiforme* and *A. tumescens* failed to produce deep yellow pigmentation. *A. tumescens*, described recently as lacking diastatic action and as producing no branching of cells, was found diastase positive and capable of producing branching cells in young subcultures. *A. tumescens* failed to grow on protein-free media; it showed marked caseinolysis on milk agar. *A. tumescens* probably should be retained as a species of *Arthrobacter* in addition to *A. globiforme*.

ECONOMIC NATURE OF THE COOPERATIVE ASSOCIATION¹

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The cooperative association for business purposes is an economic institution through which economic activity is conducted in the pursuit of economic objectives. Economic concepts are basic to the sound organization and operation of cooperatives, to the solution of practical cooperative problems, and to public policies regarding cooperative activity consistent with society's objectives. Yet the voluminous literature on business cooperation is dominated by socio-reformistic, historical, and descriptive interpretations. Little has been written concerning the basic economic nature of the cooperative association. Of the contributions in this area, the writings of Nourse,³ Emelianoff,⁴ and Robotka⁵ have been drawn on most heavily in the thesis.

The analysis used is primarily that of deductive economic logic. Following a review of the literature dealing specifically with the subject of the thesis, the fundamental structure in the cooperative association is developed. Next the economic relationships among the participating units arising in the cooperative association are examined. Then the conditions for profit maximization in firms participating in the joint activity are studied in some detail. Under dynamic conditions stability as well as efficiency objectives are considered. Finally a few important applications of the concept of the nature of the cooperative association are indicated.

When two or more economic units cooperate with respect to some function or

activity that is integrally related to their individual economic operations, the result is not a new firm; instead it is a common economic plant. The cooperative association consists of the sum of the multi-lateral agreements among the firms participating in the joint activity, in order that these firms may function coordinately through their common plant. The cooperative activity is an economic plant operated jointly as a part of these several firms. The cooperative, as such, has no entrepreneurial unit; each of its member units has its entrepreneur. Except for the coordination necessary to enable a group of economic units to operate a common plant jointly, the member units function independently of one another in the pursuance of their individual economic careers. Each participating firm arrives at production equilibrium considering its separate activities *plus* its proportionate share of the joint activity as an integrated production unit.

The participating firms usually do not share their joint plant equally. The proportion of the total joint plant included as a part of each of the participating firms is defined by the relative size of the production activities in the individual plant (or plants) of each firm with which the activities conducted through the joint plant are integrated. This *proportionality* determines the manner in which the participating firms will share all inputs, including entrepreneurial inputs, and all outputs—all costs and benefits—of the joint plant. In order to achieve optimum allocation of resources among the participating firms, the entrepreneurial decisions, the bearing of uncertainties, the financial responsibility, the economic use, the costs, and the economic benefits in connection with the joint activity must be shared by the firms on the basis of this proportionality. Under conditions of uncertainty and imperfect knowledge, *planned* proportionality, rather than *actual realized* proportionality, determines the manner in which the participating firms will share these economic functions in the joint plant, including those which extend over time and between departments.

1 a. Chairman of Committee, Frank Robotka, Dept. of Economics and Sociology.

b. Doctoral Thesis No. 1289. Submitted June 7, 1952.

2 a. B.S., Iowa State College, Ames, Iowa, 1948. M.S., *ibid.*, 1949.

b. Assistant Professor, Agricultural Experiment Station.

3 Cf. Nourse, Edwin G. *The Legal Status of Agricultural Cooperation*. The Macmillan Co. New York. 1927.

4 Cf. Emelianoff, Ivan V. *Economic Theory of Cooperation*. Ivan V. Emelianoff. Washington, D. C. 1942.

5 Cf. Robotka, Frank. *Lego-Economic Implications of Cooperation*. In *American Cooperation*; 1946. p. 522-533. American Institute of Cooperation. Washington, D. C. 1946, and Robotka, Frank. *A theory of Cooperation*. *Journal of Farm Economics*. 29:1:94-114. 1947.

The participating firms are ordinarily vertically integrated in the sense that the output of the joint plant is raw product input of the individual plants of the participating firms, or alternatively the output of the individual plants of the participating firms is the raw product input of the joint plant.⁶ As products move from one plant to another in a vertically integrated firm, no transfer of title takes place and no price is established for them. Such a firm is not interested in the profitability of any one of its plants considered alone, but rather in the profitability of the complete chain of integrated plants operated as a unit. The cooperating firm maximizes its profits, assuming best production combination, by equating the sum of the marginal cost in its individual plant or plants and the marginal cost in the joint plant with the marginal revenue facing the firm in the market where the product is sold.⁷ This criteria applies both to short run and to long run analyses.

The relevant segment of the marginal cost function in the joint plant to each participating entrepreneur is that beginning with the sum of the equilibrium outputs of all other participating entrepreneurs. Each entrepreneur must consider the additional costs in the joint plant resulting from his volume of output. Formal solution of the optimum output for each participating firm in the joint plant, given the number of participating firms, is possible by simultaneous equations only. If the output product of the participating firms is marketed from their joint plant, all that has just been said about the relevant range of the joint plant marginal cost curve to each firm applies also to the relevant range of the marginal revenue curve.

One reason firms find it economic to operate a plant jointly, rather than carry out the same production processes individually, is a decreasing long run average cost curve over a considerable range for a part of the total economic function, or contemplated function, of the several firms. Once several firms agree to set up and operate a plant jointly, they are

interested in obtaining the size in their joint plant which will maximize plant efficiency and make the greatest possible contribution to the profits of each participating firm. Plant size is reduced by failure to replace firms that retire from participation, and expanded by encouraging new firms to participate.

The joint plant will be of optimum size when the long run average net return from the plant is a maximum; the greatest contribution of the plant to the profit of each participating firm, regardless of the size of the firm, will be at this point. Where the output of the joint plant is raw product or specific resource input for the individual plants of the participating firms, optimum size in the joint plant is defined by the minimum point in the long run average total cost function in the joint plant. Where the output of the individual plants of the participating firms is the raw product input of the joint plant, the optimum size for the joint plant is defined at the output which maximizes the vertical distance between the long run average revenue curve and the long run average cost curve in the joint plant. The joint plant long run average cost curve in this case is net of the cost of raw product in-puts supplied from the individual plants of the participating firms.

Under dynamic conditions, the participating firm must consider not only the maximum expected discounted value of the profit stream, but also the minimum expected variation in this stream over time. Given the production plan which maximizes the discounted value of the expected stream of profits, and the production plan which minimizes the expected dispersion around the most probable profits over time, the participating entrepreneur selects the compromise position between the two most acceptable to him. The location of this compromise position for given participating firm will be defined by the point of tangency of the "technical" relationship function between these two objectives, and an indifference curve of the entrepreneur defining the relative importance of the two objectives to him. The only rational segment of the technical relationship function is the range where the two objectives are competitive; the entrepreneur can improve his position by moving into this range, regardless of the slope and shape of his indifference curves toward the two.

The concept of the basic economic structure of the cooperative association, and the interfirm relationships resulting

6 The exception is the plant operated jointly by two or more firms to procure specific capital resources, such as farm machinery for agricultural firms. In this case each participating entrepreneur will equate the marginal cost in the joint plant with the marginal revenue productivity of the resource in his individual plant.

7 Cf. Hirsch, Werner Zvi. *The Economics of Integration in Agricultural Marketing*. Unpublished Ph. D. Thesis. Univ. of California Library. Berkeley. 1950. p. 97-144. Hirsch does not deal with this general case, although it follows logically from his analysis.

from the joint ownership and operation of a common plant, should provide an important working tool to the applied economist, the cooperative attorney, the cooperative accountant, the practical cooperative leader, and the legislator alike.

And it should avoid the insurmountable difficulties and inconsistencies which arise when the cooperative is looked upon as a firm and its operations are studied apart from the individual operations of the participating firms.

EFFECTS OF TESTOSTERONE PROPIONATE ON THE SEMINAL VESICLES OF THE RAT¹

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Physiological changes are known to occur when the sources of the testis hormone, testosterone, are removed from the animal. However, the way in which this hormone functions and the exact site of the biochemical lesion induced by its absence are unknown. It was the purpose of this investigation to observe the effects of the absence and presence of the testis hormone on the chemical activities as well as physiological responses of one of the more responsive target organs to this hormone. This investigation consists of a biochemical and physiological study of the normal development of one of the accessory organs, the seminal vesicles, of the white rat as well as the effects of castration and hormone replacement on this organ of the castrate.

In the normal development of the seminal vesicles of the rat, it was found that the increase in the dry weight of the secretion-free gland was a linear function of the body weight in animals weighing approximately 150 gm. or more. This relationship is expressed by the equation $Y = 0.3371x - 40.43$ and is significant at $P = 0.01$. The total nitrogen content of the seminal vesicles of prepubertal rats was 0.3 mg.; whereas, the nitrogen content of these glands in rats weighing 146 gm. was 1.2 mg. and it increased to 13.6 mg. in rats weighing 385 gm. The lipid content increased from 0.3 mg. in rats weighing 146 gm. to 4.4 mg. in rats weighing 385 gm. The per-

centage dry weight changed little during development. The composition of the seminal-vesicle secretion on a percentage basis was as follows: 25.9 dry weight; 13.6 nitrogen; 1.6 ash; 0.44 non-protein nitrogen; and 0.35 total reducing substances. This secretion contained no lipid.

In the case of animals with a mean weight of 275 gm., castration caused the weight of the seminal vesicles to decrease 35 per cent after 2 days, 49 after 5 days, 62 after 10 days, and 73 after 20 days. Two days after castration there was a 78 per cent decrease in the amount of secretion initially present and after 5 days there was a 98 per cent reduction. The catheptic activity of these glands changed little during the first 3 days after castration; however, this activity gradually decreased to 0.9 of a unit after 24 days in contrast to 2.8 units at the time of castration. The total nitrogen content per gland decreased 74 per cent by the twentieth day after castration. During this same interval of time, the concentration of alkaline phosphatase activity decreased 45 per cent; whereas, the acid phosphatase activity remained constant. However, the activities of the alkaline and acid phosphatase per gland decreased 81 and 65 per cent, respectively. The Q_{50} of seminal-vesicle tissue was not altered by castration.

The daily injection of testosterone propionate (500 micrograms per day) into castrate rats for 20 days resulted in the following increases per gland: dry weight, 11 to 123 mg.; nitrogen, 0.2 to 7.3 mg.; secretion, 0 to 1322 mg.; alkaline phosphatase, 1.3 to 62.8 units; and acid phosphatase, 0.1 to 11.5 units. The catheptic activity of rats that were injected over a 10 day period changed from 0.9 to 4.5 units. The catheptic and alkaline phosphatase activities, as well as total nitrogen

1. Chairman of Committee, R. M. Melampy, Dept. of Zoology and Entomology.

b. Doctoral Thesis No. 1273. Submitted May 31, 1952.

2. B.A., Baylor University, Waco, Texas, 1949. M.A., Texas Technological College, Lubbock, Texas, 1950.

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of the seminal vesicles of these rats, changed little during the first 2 days of hormone injection. From the second to the fifth day of injection the catheptic activity per gland and the total nitrogen increased 200 and 275 per cent, respectively, and the alkaline phosphatase activity per gland showed a 1064 per cent gain. Furthermore, the acid phosphatase activity increased 520 per cent during the same time, although the relative activity of this enzyme was much lower than that of

alkaline phosphatase. A marked accumulation of secretion appeared after the fifth day. The Q_{90} of rat seminal-vesicle tissue was significantly greater 2 days after hormone treatment than that of castrates. However, this rise decreased after this time and by 20 days of hormone treatment there was no significant difference between the Q_{90} of seminal-vesicle tissue of injected and uninjected castrates.

A SIMPLIFIED INSTRUMENT FOR THE MEASUREMENT OF TURBIDITY AND ITS APPLICATION IN OVALBUMIN DENATURATION STUDIES¹

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Light scattering provides a means for determining the molecular weight of purified proteins and/or following the change in particle weight under varying conditions. Most investigators applying light scattering methods to the study of proteins have been concerned with obtaining little or no denaturation. Changes in particle size frequently accompany denaturation and light scattering provides a very convenient method for following these changes. It seemed desirable to apply light scattering techniques to the denaturation problem.

A simplified instrument is described for the measurement of 90° scattering and dissymmetry. It is a visual instrument employing the optical system of a Zeiss Pulfrich photometer for measuring the intensity of the scattered light. Measurement of turbidities of the order of $2 \times 10^{-4} \text{ cm}^{-1}$ is possible and measurements may be made at angles from -135° to $+135^\circ$ with respect to the incident beam.

The instrument was calibrated using carbon disulfide of known scattering power, a polystyrene solution of known turbidity, a magnesium carbonate surface

of known reflectivity and an aqueous solution of colloidal silica. The turbidity of the colloidal silica solution was determined directly with a Beckman D. U. spectrophotometer.

The specific refractive index increments were determined for the solutions studied by using the optical system of an electrophoresis instrument. A divided cell was used to hold solvent and solution. The displacement produced was measured with a traveling telescope and the value obtained related to the refractive increment. The specific refractive index increments obtained were 0.188 for ovalbumin, 0.194 for bovine serum albumin, 0.187 for lysozyme and 0.149 for amyloheptaose ($\lambda = 5461 \text{ \AA}$).

The molecular weights of bovine serum albumin, ovalbumin, and lysozyme were obtained for the native purified protein in phosphate buffer solution (pH 7.80). The molecular weight of bovine serum albumin was found to be 72,500, ovalbumin was 46,200 and lysozyme was 13,400 under the conditions of the investigation.

The molecular weight of amyloheptaose as determined by light scattering was found to be 1050 as compared to the calculated value of 1152.

Methods were found for determining significant particle weights of heat denatured ovalbumin. It was found that concordant results could be obtained only when the ionic strength was adjusted to 0.015 or greater. However, aggregation

- 1 a. Chairman of Committee, Joseph F. Foster, Dept. of Chemistry.
b. Doctoral Thesis No. 1185. Submitted June 15, 1951.
- 2 a. B.S., Utah State Agricultural College, Logan, Utah, 1940.
M.S., *ibid.*, 1944.
b. Assistant, Industrial Science Research Institute.

of the denatured protein is promoted by increasing the ionic strength necessitating avoidance of excesses of salt and requiring measurement of the turbidities of the solutions immediately after the addition of salt.

At pH below or above the isoelectric point the observed molecular weight of native ovalbumin in salt free solutions was found to be low. This is in accord with the work of other investigators and is probably due to the decreased turbidity resulting from long range interactions between the charged protein molecules and to the inability of the instrument to measure the turbidities of solutions of extremely low protein concentration. Addition of salt solutions to protein solutions causes an immediate rise in turbidity and the molecular weight of native ovalbumin in solutions having an ionic strength of .015 or greater is that expected for this protein. The molecular weight of ovalbumin in solutions near the isoelectric point was apparently independent of the ionic strength of the solution.

The rate of aggregation after addition of salt to denatured protein solutions increases as the ionic strength and/or the concentration increases. The rate of aggregation increases as the isoelectric point is approached.

Heat denaturation of ovalbumin near the isoelectric point produces coagulation. If however, the pH of a salt free sample was decreased before heating, the solution remained clear and light scattering measurements showed that aggregation decreased with pH, reaching a minimum at a pH of 2.40 where the apparent molecular weight corresponded to that of the native sample. As the pH was further decreased the aggregation produced during heat denaturation was increased. This increase was probably due to the increased ionic strength at time of heating arising from the addition of HCl to adjust the pH to the low value. A similar situation was found to exist on the alkaline side of the isoelectric point. The apparent molecular weight of the heat denatured ovalbumin decreased with increasing pH, approaching the value for native ovalbumin at pH 9.6. As the pH was increased above 9.6 the apparent molecular weight increased. Here, again, the ionic strength

was increased by the necessary addition of NaOH to raise the pH and may account for the noted aggregation.

The turbidities of unheated ovalbumin samples were measured over the pH range 1.5 to 11.5 and the apparent molecular weights were calculated from the results obtained. At pH 1.5 a particle weight of 114,000 was found indicating aggregation and suggesting the possibility that the protein was no longer "native" under these conditions. From pH 2.0 to 10.5 the values obtained indicated little or no aggregation except for the value obtained at the isoelectric point. At the isoelectric point the apparent molecular weight found was 68,000. This value is not surprisingly high when one considers the lability of ovalbumin and its increased tendency to aggregate at the isoelectric point. Aggregation was in evidence at pH values higher than 10.5. This increase in apparent molecular weight possibly was caused by denaturation and aggregation at extremes of pH.

Most of the denatured samples were heated 15 minutes at 100°C. Variation in the length of time of heating influenced the apparent molecular weight. Longer heating promotes greater aggregation. The effect of heating time does not appear to be as pronounced at lower ovalbumin concentrations.

The extent of aggregation was influenced by the concentration of the protein solution at the time of heating. Variation in the concentration at pH 2.40 and 8.65 indicated an increase in aggregation with increasing concentration. The effect was less pronounced at pH 2.40.

Dissymmetry measurements were influenced by sample history to such an extent that conclusions could not be reached as to the dissymmetry of heated and native ovalbumin. It seems, however, that the dissymmetry of heat denatured ovalbumin lies between 1.05 and 1.25 corresponding to a length of 400-800 Å (assuming a rod). No significant difference in dissymmetry was observed between samples showing little or no aggregation and those having particle weights up to 20 times that of the native ovalbumin. This lends support to the idea that ovalbumin aggregates laterally and not end to end.

VITAMIN B₁₂ REQUIREMENT OF THE WEANLING PIG¹

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The superiority of animal protein over plant protein for feeding swine has been found to be largely due to vitamin B₁₂. Added vitamin B₁₂ has proved to be of practical benefit in swine rations low in this nutrient. This study was made to determine the amount of vitamin B₁₂ required in the ration of the weanling pig to permit optimum growth.

In the first experiment, six sets of four male litter mate pigs were fed and watered, *ad libitum* from weaning to 75 pounds in 18 by 40 inch wire floored wood crates. The pigs were produced by sows fed an adequate ration, including animal protein, during gestation and an all plant ration during lactation. When placed upon experiment, the pigs were fed a corn-soybean oil meal basal ration fortified with minerals, including trace minerals, and all known vitamins except ascorbic acid and vitamin B₁₂. Crystalline vitamin B₁₂ was added to this ration at levels of 0, 5, 10 and 20 micrograms per pound of total ration. The ration treatments were subdivided with one half of the pigs receiving 10 milligrams each of aureomycin hydrochloride, terramycin hydrochloride, streptomycin sulfate and procaine penicillin G per pound of total ration.

The addition of 0, 5, 10 and 20 micrograms of crystalline vitamin B₁₂ per pound of total ration produced average daily gains of 1.19, 1.22, 1.25 and 1.29 pounds respectively. When the combination of antibiotics was added, the same levels of vitamin B₁₂ produced average daily gains of 0.91, 1.54, 1.58 and 1.53 pounds respectively. Pigs on the basal ration did not gain as fast with the addition of antibiotics. When antibiotics and vitamin B₁₂ were fed together, the rate of gain was greatly increased and there were no differences in weight gains of pigs between added levels of crystalline vitamin B₁₂. It is believed that the antibiotics inhibited the microflora

of the digestive tract which compete with the pig for vitamin B₁₂ and also those which may synthesize vitamin B₁₂. Therefore, those pigs which had vitamin B₁₂ supplied in the ration gained rapidly, whereas those that did not receive vitamin B₁₂ in the ration, and also had the synthesizing organisms inhibited, did poorly because of vitamin B₁₂ deficiency. The addition of vitamin B₁₂ increased feed efficiency.

There were no differences in hemoglobin, red and white blood cell counts and total nitrogen among treatments. Antibiotics alone increased blood urea; however, when vitamin B₁₂ was added, the blood urea was lowered.

Vitamin B₁₂ assays of the urine and feces showed a tendency for the amount to increase as the amount of vitamin B₁₂ fed was increased. The assay values showed greater amounts than could be accounted for in the feed. This further indicated synthesis of vitamin B₁₂ in the digestive tract. Liver vitamin B₁₂ assay values increased as the amount fed was increased. The results indicated that 10 micrograms or less per pound of ration permitted maximum storage in the liver.

The results of two pilot experiments indicated effective carry-over value from vitamin B₁₂ storage to be about five weeks with pigs whose dams had vitamin B₁₂ supplied in the ration during the lactation period, and that greater amounts of antibiotics seemed to exert better control of the microflora in the digestive tract.

The results of the first experiment indicated that the nutritional requirement of the weanling pig for vitamin B₁₂ is 5 micrograms or less per pound of total ration. The second experiment was designed to determine more closely the exact requirement. Six sets of four litter mates were produced, fed and managed as in the first experiment except that ascorbic acid was added to the basal ration and the antibiotics increased to 20 milligrams each of aureomycin hydrochloride, terramycin hydrochloride, streptomycin sulfate and procaine penicillin G per pound of all rations. Crystalline vitamin B₁₂ was added to the basal ration at levels of 0, 2, 4 and 6 micrograms per pound of total ration.

- 1 a. Chairmen of Committee, L. A. Underkofler and Damon Catron, Dept. of Animal Husbandry.
b. Doctoral Thesis No. 1205. Submitted August 18, 1951.
- 2 a. B.S., Clemson Agricultural College, Clemson, S.C., 1938.
M.S., Iowa State College, Ames, Iowa, 1950.

The average daily gains to 75 pounds were 0.98, 1.22, 1.34 and 1.34 respectively when 0, 2, 4 and 6 micrograms of vitamin B₁₂ were added per pound of ration. While carrying the pigs to 100 pounds liveweight, three pigs on the basal ration showed vitamin B₁₂ deficiency and developed growth stasis. Injection and feeding of vitamin B₁₂ to these deficient pigs produced average daily gains of 1.18, 1.59 and 1.42 pounds as compared with 0.77, 0.78 and 0.56 pound respectively before receiving vitamin B₁₂. These dramatic results prove that vitamin B₁₂ is essential for the weanling pig. Feed efficiency was increased with the addition of vitamin B₁₂.

There were no significant differences in hemoglobin, red and white blood cell counts. Blood of the basal ration pigs showed less total nitrogen and there was a decided decline in blood urea as the amount of vitamin B₁₂ fed was increased. This indicates that vitamin B₁₂ enhances the utilization of nitrogen. The average weights of livers showed a downward trend as the vitamin B₁₂ fed was increased; however, the amount of vitamin B₁₂ per gram of liver and the total amount of vitamin B₁₂ per liver increased.

The assay values of vitamin B₁₂ in the feces and urine again showed greater amounts than could be accounted for in the feed. Assay of contents of the small intestine, cecum and large intestine from 12 pigs indicated synthesis of vitamin B₁₂ or

vitamin B₁₂ like substance(s) in the lower part of the pig's digestive tract.

Conclusions:

1. The nutritional requirement of vitamin B₁₂ for the weanling pig, fed a fortified corn-soybean oil meal ration with a combination of antibiotics for partial control of intestinal microflora, is 4 micrograms per pound of total ration.

2. Antibiotics inhibit intestinal microflora which compete with the pig for vitamin B₁₂ and also microflora which synthesize vitamin B₁₂.

3. Feeding vitamin B₁₂ did not cause any significant differences in hemoglobin, red and white blood cell counts or total nitrogen in the blood. There was a tendency for total nitrogen in the blood to be less when vitamin B₁₂ was not fed.

4. Feeding vitamin B₁₂ reduced blood urea levels.

5. Liver weights decreased as the amount of vitamin B₁₂ fed was increased but the total vitamin B₁₂ in the liver increased.

6. There is sufficient storage of vitamin B₁₂ in the weanling pig for effective carry-over value for about 3 to 8 weeks.

7. A corn-soybean oil meal ration with a combination of antibiotics can be used to produce vitamin B₁₂ deficient pigs.

8. There is synthesis of vitamin B₁₂ or vitamin B₁₂ like substance(s) in the lower part of the pig's digestive tract.

INVERTED TRIODE AMPLIFIERS¹

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The use of inverted triodes³ in amplifier circuits has received very little attention by workers in the electronics field. The plate-input grid-output circuit has been used occasionally as the input circuit for high-voltage vacuumtube voltmeters. No

critical study of the gain, input admittance, or output admittance characteristics of any inverted amplifier is found in the literature.

The specific purpose of this investigation was to study analytically and experimentally the three inverted modes of operation of a triode vacuum tube:

1. Plate-input grid-output amplifier

2. Plate-input cathode-output amplifier

3. Cathode-input grid-output amplifier.

The three inverted modes of operation are analogs, respectively, of plate-loaded amplifiers, cathode-follower amplifiers, and grounded-grid amplifiers.

The investigation included studies of the static characteristic curves of typical

1 a. Chairman of Committee, George R. Town, Dept. of Electrical Engineering.

b. Doctoral Thesis No. 1269. Submitted May 29, 1952.

2 a. B.S., University of Kansas, Lawrence, Kan., 1941.
M.S., *ibid.*, 1947.

3 In inverted operation the roles of the grid and plate, in respect to normal operation, are interchanged. The plate is operated with a negative bias voltage and the grid is operated at a positive bias voltage. Current flows in the grid circuit and not in the plate circuit for most types of inverted operation.

triodes and of the inverse mutual conductance, inverse amplification factor, and the dynamic grid resistance in the various regions of inverted operation. Analytical expressions which were derived include the general and specialized expressions for gain, input admittance, and output admittance for the three inverted amplifiers. Typical numerical values for gain, input admittance, and output admittance are calculated. A study was made of the equipotential lines in an inverted triode. Experimental values of gain and distortion for inverted amplifiers under typical operating conditions were obtained.

Several triodes with different electrical characteristics and different mechanical construction were studied. Since the general behavior of all types studied appeared to be similar, only one type, the 6J5, was studied in detail.

The static characteristic curves of inverted triodes were found to be regular and similar to the curves of conventional triodes. An exception was found in the regions in which the negative plate voltage has a small value. In these regions the curves may be quite irregular and may possess maxima and minima. In these same regions the inverse amplification factor and inverse mutual conductance may be negative as well as positive or zero. The dynamic grid resistance, however, is positive in all of the inverted regions which could be investigated.

Voltage amplifier triodes such as the 6J5, 6C5, and 2C22, when used as inverted triodes, were able to pass grid currents in excess of 10 ma at positive grid voltages of 10 volts with no damage to the grids or other parts of the tubes. This amount of current is permissible because the grid of an inverted triode is able to radiate much of its heat to the plate.

The voltage gain of the plate-input grid-output and plate-input cathode-output amplifiers is approximately the same except for a phase difference of 180 degrees. The gain of both amplifiers, under ordinary conditions of operation, has a maximum value which approaches the value of the inverse amplification factor. The inverse amplification factor is approximately equal to the reciprocal of the conventional amplification factor, or about 0.04 for a 6J5

triode. The gain of a cathode-input grid-output amplifier approaches a maximum value of unity under usual operating conditions.

The shunt capacitance of both the plate-input grid-output and plate-input cathode-output amplifiers is approximately equal to the sum of the grid-plate and plate-cathode capacitances. For triodes such as the 6J5 the shunt input resistance is above 50 megohms for frequencies up to 150 kc and for resistive loads. The shunt input capacitance of a cathode-input grid-output amplifier is somewhat less than the sum of the plate-cathode and grid-plate capacitances. The input resistance is approximately equal to the load resistance, or five to fifty thousand ohms.

The output impedance of all three types of inverted amplifiers is nearly equal to the dynamic grid resistance, or about 500 ohms for receiving type triodes.

The amount of harmonic distortion in both plate-input grid-output and plate-input cathode-output amplifiers is very low. For signal voltages as high as 100 volts, the total harmonic distortion is less than 2 per cent for properly chosen values of load resistance and bias voltage. Serious distortion occurs if the dynamic swing of the signal voltage carries the operating point into the nonlinear region of the characteristic curves. The amount of harmonic distortion in a cathode-input grid-output amplifier tends to be rather high. The input signal to this amplifier cannot be greater than about 10 volts if excessive distortion is to be avoided.

Plate-input grid-output and plate-input cathode-output amplifiers can be used as impedance-matching networks. In this application they can be used to match tens of megohms to a few hundred ohms with considerably more output voltage than can be obtained with static networks. High voltages can be applied to the input terminals of either of these two amplifiers without producing undesirable amounts of harmonic distortion. Small transmitting triodes which have the plate cap on top of the glass envelope would provide enough insulation resistance to permit the application of several thousand volts of signal and bias voltage.

NATURE OF PIGMENTS IN CONCORD GRAPES AND THEIR BEHAVIOUR DURING HEAT PROCESSING AND STORAGE¹

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Department of Food Technology (Horticulture)

An investigation was made to find the nature of the pigments present in Concord grapes with emphasis focused on the water soluble pigments. The absorption values of the pigment extracts, obtained by using the Coleman Spectrophotometer model 11, aided in the identification of the nature of the pigments. Fractionation techniques involving dialysis, solubility differences of the pigments in various solvents and ion exchange did not give any indication of the presence of more than one anthocyanin pigment in grapes. Qualitative tests of the methanolic extract of the grape skins showed the presence of chlorophyll, water soluble yellow pigments and carotenes in addition to the anthocyanin pigments. These observations were supported by the chromatographic techniques wherein magnesium, sucrose and alumina were employed as the absorbents.

Chromatograms run at $70 \pm .5^\circ\text{F}$. by using Whatman No. 4 filter paper strips as the supporting material and the non-aqueous layer of the mixture of butanol, acetic acid and water (4:1:5 by volume) as the partitioning solvent showed a greenish yellow band moving along with the solvent front and this band was found to be due to fat soluble pigments. The paper chromatogram also revealed the presence of two water soluble pigments which formed purple and red bands on the chromatogram possessing R_f values of .11 and .19 respectively. A hazy red band with an R_f value of about .56 was also noted. This red band faded in intensity in the course of 24 hours. These bands with R_f values of .56, .19 and .11 were identified as the anthocyanidin and its mono- and di-glycosides respectively by hydrolysis and separation procedures.

The major anthocyanin pigment present in Concord grapes was isolated from fresh ripe skins as the chloride. Attempts to crystallize the pigment were not suc-

cessful. However, the substance was found to be free from metallic and organic impurities. The empirical formula of the substance ($\text{C}_{28}\text{H}_{32}\text{O}_{12}\text{Cl}$) and the color reactions indicated that the pigment may be oenidin 3-monoglycoside. This assumption was supported from its R_f value (0.21) obtained by using paper strip chromatography. The sugar present in the pigment molecule in glycosidic form was identified as glucose from paper chromatogram studies.

The later part of this investigation was intended to find the changes in anthocyanin pigments, present in grape juice samples and in anthocyanin chloride solutions, resulting from thermal processing and storage. The pigment concentration in anthocyanin solutions and grape juice samples was found to be proportional to the optical densities of the clear solutions at pH of 1.0 and at $515 \text{ m}\mu$ determined by using the Coleman spectrophotometer.

Fresh Concord grapes were processed in glass jars for varying lengths of time at temperatures of 170°F ., 210°F . and 250°F . The process times were chosen in such fashion that their logarithmic values were approximately in an arithmetic progression. The process temperatures were likewise fixed on the assumption that the effect of process times was logarithmically related to process temperatures. The concentrations of anthocyanin pigment in the grape juice samples did not indicate any significant variations as a consequence of processing at different times and temperatures.

To prevent fermentation during storage, half the number of samples were pasteurized at 180°F . for one minute and to the other half one ml. of toluene was added. Half the grape juice samples were left exposed to light from electric bulbs and the other half were kept in the dark. Nitrogen was filled into the headspaces of half of the pasteurized samples and all the samples were stored at a constant temperature of $70 \pm 0.5^\circ\text{F}$. The pigment concentrations in the juice samples were determined at intervals of two months over a six month period. The results indicated

1. a. Chairman of Committee, Robert Tischer, Dept. of Food Technology (Horticulture).
b. Doctoral Thesis No. 1184. Submitted June 23, 1951.
2. a. B.Sc., Andhra University, India, 1943.
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that the pigment concentrations in the juice samples were reduced with increasing storage periods, and, of the variables tested, storage period showed the maximum influence in the deterioration of the pigment. Paper strip chromatographic studies of the stored juices at the end of each storage period indicated that the two major bands of purple and red colors, observed with fresh juice samples, became less intense with increasing storage period. With increasing storage period a brown band also appeared which moved along with the solvent. Exposure of the developed chromatogram to ammonia also revealed the presence of a yellow band with an R_f value of 0.52. Discolorations were also shown on spraying neutral ferric chloride solutions on these bands indicating that the bands were due to phenolic substances. These phenolic substances are probably formed by oxidative changes brought about in the anthocyanin pigments, and these changes are augmented by increased storage periods.

The juice samples prepared by using grapes stored at 40°F. for one month and processed for longer process times at temperatures of 210°F. and 250°F. showed deterioration on storage, identical with those observed in juice samples processed from fresh grapes. The anthocyanin pigment was destroyed if processes were conducted for process times longer than 63 minutes at 250°F.

Anthocyanin chloride solutions were processed in glass jars using times and temperatures identical with those used

for processing grapes. The results indicated increasing destruction of the pigment when the processes were for longer times and at higher temperatures. On storage, the pigment in the processed anthocyanin chloride solutions was destroyed with the simultaneous formation of insoluble brown residues. The destruction of pigment on processing and subsequent storage was found to be more striking in the case of anthocyanin chloride solutions than in the grape juice samples.

An effort was made to find the component normally present in grape juice which is responsible for protecting the anthocyanin pigment from oxidative changes, found to take place with ease of the anthocyanin chloride solutions. In an attempt to accelerate the oxidative changes, the samples of grape juice and pigment solutions were exposed to ultraviolet light. Of the grape juice components, tannins exerted the maximum influence in preventing destruction of the anthocyanin pigment present in grape juice samples of pH 3.4. Dextrose, citrus pectin, tartaric and malic acids did not seem to prevent the pigment from being destroyed. The extract of tannins obtained from grape juice seemed to possess better antioxidant properties than the extract of tannins from grape stems or tannic acid (galloyl gallic acid) solutions. The results also indicated that, in addition to tannins, other polyphenolic substances present in grape juice exert similar antioxidative effects preventing destruction of the anthocyanin pigment.

CHEMISTRY OF THE β -PHENYLSERINES¹

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The literature concerning the phenylserines was extensively reviewed, so that apparent contradictory findings and possible areas for future research might be delineated. Attention was given to synthetic methods, chemical reactions, potential biochemical significance, steric configuration, and heterocyclic analogues.

The most suitable route found for phenylserine synthesis was that described in German patent 632,424, by the directions of which benzaldehyde was condensed with glycine in aqueous sodium hydroxide. An attempt to extend the method to synthesis of β -2-furylserine was unsuccessful.

Independently of parallel work in other laboratories, phenylserine was converted via lithium aluminum hydride reduction of its esters to racemic chloramphenicol. The *threo* configuration of the amino acid was thus confirmed.

The disputed claim of E. Erlenmeyer,

- 1 a. Chairman of Committee, Sidney W. Fox, Dept. of Chemistry.
b. Doctoral Thesis No. 1215. Submitted September 25, 1951.
- 2 a. B.A., University of British Columbia, Vancouver, British Columbia.
M.A., *ibid.*, 1942.
b. Assistant, Industrial Science Research Institute.

Jr., that, although benzaldehyde-glycine condensation furnishes phenylserine as the main product, small amounts of a more soluble diastereomer are also formed, has been confirmed. Fischer esterification of condensation reaction tail crops yielded a new ethyl ester hydrochloride, much less soluble than that of phenylserine. Cold alkaline hydrolysis of this compound produced a new hydroxyamino acid, which was named allophenylserine after conversion of its ethyl ester to *erythro* intermediates in the chloramphenicol series had established its structural relation to allothreonine. Phenylserine and allophenylserine were individually but incompletely recovered from crude condensation products by making use of the solubility relation inversion observed in proceeding from the free amino acids to the corresponding ethyl ester hydrochlorides.

Phenylserine and allophenylserine were effectively separated on paper chromatograms by use of a mixture containing *n*-butanol, aqueous ammonia and acetone. Optimum conditions were established for employing paper chromatography as an analytical tool with these isomers. Threonine and allothreonine were likewise separated by means of the same solvent mixture.

The relation of the time allowed for benzaldehyde-glycine condensation to phenylserine diastereomer ratio in crude products was studied. With increasing condensation time, the allophenylserine level declined rapidly, whereas the yield of phenylserine approached a maximum. New intermediates in the condensation reaction were recognized but not isolated. A reaction mechanism was offered to explain why phenylserine and isodiphenylhydroxyethylamine, both possessing a *threo* configuration, are the preferred products of

benzaldehyde-glycine condensation, rather than their respective diastereomers.

Solvates of allophenylserine were prepared with water and with dioxane. The ratio of hydroxyamino acid to solvent is 2:1 for both compounds. Isomerically pure phenylserine and allophenylserine were fractionated with high recoveries from the crude product of one hour condensation runs. Effective separation was based upon the finding that, although allophenylserine is more soluble than phenylserine in many aqueous organic solvents, its dioxane adduct is very poorly soluble. The decomposition temperatures of phenylserine and allophenylserine, as well as those of their solvates and of their mixtures, were markedly alike and fairly sharp in the range 183-197°, variation being encountered in accord with initial bath temperature and heating rate.

The hydrochlorides of phenylserine and allophenylserine, both melting at 159-160°, were prepared by treatment of the individual amino acids with hydrogen chloride gas in dioxane. By use of a modified Fischer method, the following ester hydrochlorides were synthesized in high yield: phenylserine methyl (m.p. 160° (dec.)), ethyl (m.p. 140°), *n*-propyl (m.p. 131°), *i*-propyl (m.p. 165° (dec.)); allophenylserine methyl (m.p. 180° (dec.)), ethyl (m.p. 178° (dec.)), *n*-propyl (m.p. 160°), *i*-propyl (m.p. 165° (dec.)). By treatment of these compounds with ammonia gas in ether, the corresponding esters were obtained in high yield: phenylserine methyl (m.p. 62°), ethyl (m.p. 84°), *n*-propyl (m.p. 59°), *i*-propyl (m.p. 75°); allophenylserine methyl (m.p. 110°), ethyl (m.p. 86°), *n*-propyl (m.p. 63°), *i*-propyl (m.p. 75°). Cold alkaline hydrolysis of the two ethyl ester hydrochlorides was demonstrated to proceed without epimerization.

PHYSIOLOGIC SPECIALIZATION AND INHERITANCE
OF RESISTANCE TO SPECIFIC RACES OF
PUCCINIA CORONATA CORDA VAR. *AVENAE* F. & L.¹

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A total of 18 differential varieties of oats were used to identify collections of crown rust in 1950. These varieties were arranged into three groupings, (1) the standard 13 differential varieties, (2) a new set containing Anthony, Victoria, Appler, and Bond of the old set plus Landhafer, Santa Fe, Ukraine, Trispermia, and Bondvic, (3) the combined set of 18 varieties. In 1951 Saia was added to the new and combined sets.

In 1950, 14 races were differentiated using the old set. The most common of these was race 45. Two new races, numbered 101 and 102, were described. Using the new set, a total of 27 races were identified, while the combined set differentiated 43 races. Calculations of the relative efficiency of the three sets were made by arbitrarily designating the value of the old set as 100. Using the total number of races identified as the criterion of efficiency, the new set had a value of 162 and the combined set, a value of 331. When the number of varieties comprising the set was considered, the new set had a value of 233 and the combined set a value of 239. On the basis of the number of races that each set could theoretically identify, the new set had a value of 1108 and the combined set a value of 4.

In 1951, 16 races were identified on the old set. Race 45 again was the most prevalent form followed by race 101. Five new races, numbered 103, 104, 105, 106, and 107 were described. Using the new set, a total of 27 races were identified, while the combined set differentiated 44 races. Using total number of races, the new set had a relative efficiency value of 163 and the combined set a value of 275. When the number of varieties comprising the set

was considered, the new set had a value of 211 and the combined set a value of 189. Using the number of races that theoretically could be differentiated by each set, the new set had a value of 616 and the combined set a value of 2.

After considering the relative efficiency of the three sets, as well as the value of the varieties comprising each of these sets, it was recommended that the new set, as composed of the 10 varieties included in 1951, be used henceforth to characterize and identify races of crown rust.

The mode of inheritance of reaction to races 1, 45, and 101 was studied in several oat crosses. Landhafer, or a Landhafer derivative presumed to carry the Landhafer type of resistance, appeared as one parent in four of the crosses studied. All four were tested with race 101 and two were tested with race 1. In every case the resistance of this variety apparently was governed by a single gene, which is in agreement with previous studies. Considerable variability, however, was evident in the degree of dominance expressed by this gene in the different crosses. It exhibited nearly complete dominance for resistance to race 101 in the cross Landhafer x Trispermia. When crossed with Reselect Clinton and tested with the same race, dominance was lacking, the heterozygotes forming a clear-cut class of intermediate reaction types. In the cross (Sac x Hajira-Joanette) x [Landhafer x (Mindo x Hajira-Joanette)] the resistance of the Landhafer gene to race 1 was recessive.

The variety Santa Fe was represented either as Early Santa Fe or as Santa Fe-Clinton in three crosses. All three were tested for reaction to race 101, and one, Cherokee x Early Santa Fe, was tested for reaction to race 45. Resistance to races 45 and 101 appeared to be inherited in the same manner. Data from the three crosses were satisfactorily explained by assuming that Early Santa Fe and Santa Fe-Clinton carried two genes for resistance linked

- 1 a. Chairmen of Committee, H. C. Murphy, Dept. of Botany, and I. J. Johnson, Dept. of Agronomy.
- b. Doctoral Thesis No. 1286. Submitted June 6, 1952.
- 2 a. B.S., Utah State Agricultural College, Logan, Utah, 1949.
- M.S., *ibid.*, 1950.
- b. Collaborator, Agricultural Experiment Station.

with a recombination value of approximately 23 per cent.

Trispermia appeared as one parent in three crosses, two of which were tested with race 101 and one with race 1. The resistance of Trispermia to these races appeared to be governed by a single gene. As with Landhafer, the degree of domi-

nance varied in the different crosses.

Two of the crosses studied. Landhafer x Trispermia and Landhafer x Santa Fe-Clinton, exhibited transgressive segregation for resistance to race 101, certain F_2 plants being more resistant than either parent.

CLOUD CHAMBER IDENTIFICATION OF PHOTODEUTERONS FROM COPPER¹

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Evidence has been reported (1,2) for the production of deuterons in the disintegration of copper and sulfur by bremsstrahlung below 24 Mev. energy. In the more direct of these investigations (1), the presence of a deuteron group was inferred on the basis of range and grain-density measurement in nuclear emulsions, and led to a ratio of photodeuterons to photoprotons cited as 0.31 for copper. Due to the bearing which such a large deuteron group must have on the theory of photonuclear processes, an independent investigation of the photodeuteron yield from copper was undertaken.

The object of the present investigation was to determine the relative yield (in equal range and solid angle intervals) of photodeuterons and photoprotons produced by the irradiation of a thick copper target with 65 Mev. bremsstrahlung. A cloud chamber traversed by a magnetic field was employed, in conjunction with the Iowa State College Synchrotron, to permit the observation of tracks formed by heavy photo particles from the copper. A determination was made of the mean curvature of each track studied, in a fixed range interval extending between 4 and 14 cm. from the end. Thus all protons had, except for straggling, a fixed energy interval and, similarly, the deuterons had another fixed energy interval.

The cloud chamber and experimental arrangement were as described by Stokes (3), except for the following features: a larger photon beam aperture was used; the photon beam traversed a copper target, 0.018 inch thick, at an angle of about 10 degrees; helium, ethanol, acetone, and water formed the cloud chamber gas; 43 of 550 turns of one coil were bypassed, due to insulation failure; and the magnetic field was turned on by an ignitron, to permit establishing the field more rapidly. The magnetic field was calibrated by means of a Marion fluxmeter, and extended by panel meter readings of the coil current.

The tracks were stereoscopically photographed and reprojected to full size; the mean curvature of the projected image was determined for each usable track by choice of the closest fitting circular arc and corrected for the inclination of the track to the magnetic field. The stopping power of the cloud chamber gas was determined from the range of polonium alpha particles. From the stopping power, the energy was calculated as a function of range for protons and for deuterons, using published range-energy data (4). The energy, or momentum, and magnetic field strength determine the radius of magnetic curvature, which was averaged over the standard interval to give the expected mean curvature for an unscattered path; the values so obtained for a proton and deuteron were 0.022 and 0.014 cm.⁻¹ respectively. For those tracks for which the average curvature was not directly measured over the standard range interval, a suitable correction was applied to the curvature. This correction was made without prior identification of the particles and was estimated from the range-energy

1 a. Chairman of Committee, L. Jackson Laslett, Dept. of Physics.

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relation for protons. The correction was less than 12 per cent except for 4 tracks; it is a fair approximation for deuterons, and, as applied, would not give a spurious contribution to the deuteron group.

Due to small angle multiple scattering in the chamber gas, the measured tracks exhibit a distribution in curvature which, for each type of particle, may be taken as Gaussian in form. This is deduced from the Gaussian character of the distribution expected for the angle of scattering, which is given by the theory of multiple scattering (5-8). The width of the distribution in curvature to be expected for protons under the conditions of the present investigation was determined by a control experiment. Knock-on protons were obtained for this purpose; neutrons, from a polonium-beryllium source, striking a plastic enclosure situated within the cloud chamber provided fast protons. Application of scattering theory (5-8) permits a simple evaluation to be made of the width expected for the curvature distribution of deuterons in terms of that found for protons. In this way 0.005 and 0.004 cm^{-1} were estimated as the $1/e$ half-widths for the proton and deuteron distributions, respectively, as they would occur in the present investigation.

The corrected curvatures of the 67 measurable tracks obtained from photonuclear reactions in the copper target were plotted in the form of a distribution curve to represent the number of tracks in a curvature interval, 0.002 cm^{-1} wide, as a function of curvature. To facilitate the interpretation, points were so plotted at increments of 0.001 cm^{-1} in curvature. A comparison of this distribution with that obtained from the control experiment, in which protons were present exclusively, clearly indicated the presence of a strong deuteron group. By use of the known width for a pure proton distribution and that expected for a deuteron group, a separation of the composite distribution into proton and deuteron components was performed without ambiguity. Since both the mean curvatures and widths of the separate distributions were known, this

analysis involved solely the adjustment of the magnitudes of the proton and deuteron abundances.

The analysis of the distribution curve permitted an estimate to be made of the relative abundance of photodeuterons and photoprotons. The deuteron to proton ratio was thus found to be 0.76³ for equal range and solid angle intervals. The particles sampled in this investigation could have been produced in the copper target with energies between 1.1 and an estimated 15 Mev. Since deuterons lose energy more rapidly along their path than do protons, the observed ratio should be divided by an estimated factor of 1.7 to obtain the relative abundance in equal intervals of energy.

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³ The digit underlined is not considered significant.

OXIDATION OF PHENOLS BY TETRAVALENT CERIUM¹

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A brief account of the discovery and early investigations on phenol itself has been given, and the subsequent rise in commercial importance of this compound traced. Some useful applications of phenols as a class have been enumerated.

Literature bearing on the detection, identification and quantitative analysis of phenols, and on their reactions with various oxidizing agents has been surveyed. Interpretations of phenol oxidation reactions by a number of investigators have been reviewed and generalization attempted.

Observations by the writer on the sulfato-cerate oxidation of phenols have been described. The typical reaction is an almost instantaneous oxidative precipitation whereby the phenol in its near entirety becomes changed to a resinous mass. Only aromatic amines and some heterocyclic nitrogen compounds may be confused with phenols in this phenomenon. Differing colors and solubility behavior of the individual resins may be used to identify them and consequently the phenol out of which they arise.

If temperature, time and concentrations are reproduced, the amount of sulfato-cerate reduced by a given quantity of a

phenol is constant and it is characteristic of the individual substance. By oxidizing known amounts of phenols in a standard procedure and charting the data, unknown quantities of the corresponding substances may be estimated. Weights of the pure resins may also be used for quantitative analysis. In view of its wide applicability, economy and convenience, the sulfato-cerate reagent is expected to assume increasing importance in phenol chemistry.

The precipitates have been investigated as to average molecular weight, elementary analysis, infra-red absorption spectra and solubility behavior. It has been concluded that the precipitates are essentially polynuclear quinones containing four to seven six-membered rings, and that they arise from the repeated combination of aroxyl radicals. Cerium reagents are unique in the extent to which they force this type of reaction.

Application of the sulfato-cerate reagent to the oxidation of di-iodotyrosine has been tested with the possibility of forming thyroxine as the question. Thyroxine was not observed to be formed under the conditions imposed, however. The resin obtained from the sulfato-cerate oxidation of meta-cresol has been observed to possess a small amount of electron-exchanging capability.

It is suggested that the phenol-sulfato-cerate phenomena may be made increasingly useful through further investigation.

- 1 a. Chairmen of Committee, G. S. Hammond, and F. R. Duke, Dept. of Chemistry.
b. Doctoral Thesis No. 1220. Submitted October 30, 1951.
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EXTENSION OF THE DISCRIMINANT FUNCTION FOR EVALUATING HIGH SCHOOL CHEMISTRY AS A PREREQUISITE FOR COLLEGE CHEMISTRY¹

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It was the purpose of this study to show the application of the discriminant function to predict three categories of academic achievement. Chemistry students were used to present the applicability of such an extension of discriminant analysis.

For purposes of this study the three categories of academic achievement in Chemistry 101 were designated as the attrition group, the average group, and the top group. The attrition group consisted of students who failed to receive a passing mark in Chemistry 101, who transferred to a decelerated course, or who dropped the course. The average group consisted of students who received a mark of C or D in Chemistry 101, and the top group consisted of students who received a mark of A or B in Chemistry 101.

The study was limited to 800 of the students in the Divisions of Engineering and Science who were registered for Chemistry 101 during the fall quarters of 1947, 1948, 1949, and 1950.

Using the trichotomy of Chemistry 101 marks as the criterion of achievement, an analysis of variance indicated that the achievement of those students who had high school chemistry was higher than for those who lacked such credit in high school. From the analysis of variance it also appeared that achievement was not uniform from year to year, but no evidence was found to suggest that a difference existed between the achievement of engineering and science students.

Scholastic aptitude was controlled by the ACE-score, prior achievement by the high school grade-point average, and mathematical ability by Carnegie units of high school mathematics. An analysis of covariance indicated a highly significant difference in achievement for those students

who had high school chemistry credit when compared to the students without high school chemistry credit. The analysis of covariance also indicated that achievement in chemistry varied from year to year, and that the usefulness of high school chemistry is not uniform from year to year.

Triserial correlation coefficients were computed between each variable and the attrition-average-top tendency of Chemistry 101 marks. These correlations were 0.4947, 0.5643, and 0.3395, for the ACE-score, high school grade-point average, and Carnegie units of mathematics, respectively. A multiple triserial r value was computed between the three foregoing variables and the attrition-average-top tendency of Chemistry 101 marks, and was 0.6673.

A discriminant function was developed using ACE-scores and high school grade-point averages as variables, and another discriminant function was developed using high school grade-point averages and Carnegie units of high school mathematics as variables.

The foregoing discriminant functions were then modified in such a way that they yielded sigma scores of attrition-average-top tendency which could be changed into chances in 100. For the convenience of counselors, probability tables were prepared showing the chances in 100 of being in the attrition-average-top group of Chemistry 101 marks.

Discriminant functions based upon information from 1947-1950 and employing the ACE-score, high school grade-point average, and Carnegie units of mathematics as variables were used to make individual prediction for 546 engineering and science students who entered college the fall quarter of 1951. As a measure of the relationship between sigma scores obtained from the discriminant functions and the trichotomy of Chemistry 101 marks received in the fall quarter of 1951, a coefficient of triserial correlation was computed. The value of this triserial correlation coefficient was 0.7546, which was slightly

- 1 a. Chairman of Committee, James E. Wert, Dept. of Vocational Education.
b. Doctoral Thesis No. 1283. Submitted June 5, 1952.
- 2 a. B.S., Gustavus Adolphus College, St. Peter, Minn., 1948.
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higher than the multiple triserial correlation obtained with the 800 students upon which the discriminant analysis was based.

The magnitude of the serial correlations indicates the usefulness of the discriminant analysis in the prediction of achievement

in chemistry. The usefulness of the discriminant analysis is also indicated when predictions resulting therefrom are just as satisfactory when applied to a group upon which the discriminant analysis is not based.

ANALYSIS OF THE EFFECTS OF UNCERTAINTY ON RESOURCE USE AND INCOME¹

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The problem of this study of Iowa agriculture was to establish:

1. Objective measures which would be indicative of uncertainty.
2. The relative degree of uncertainty existing between various organizations and physical environments.
3. The effectiveness of various precautions the firm may take against uncertainty.
4. The effectiveness of methods by which society might combat the resource inefficiency of individual precautions to uncertainty.

The variability in budgeted net income from several patterns of resource use over the period of years from 1917 to 1948 was selected to measure uncertainty. The selection of this measure of uncertainty is based on the premise that income variability indicates the existence of uncertainty and differences in income variability indicate differences in the relative degree of uncertainty existing. The standard deviation, coefficient of variation, mean of first differences and relative mean of first differences were the objective measures used to indicate the existence of uncertainty.

It was indicated that differences in physical yields give differences in uncertainty among the five type-of-farming areas of Iowa. The indicated relative degrees of uncertainty in the five type-of-farming areas were as follows, in descending order of degree: Southern pasture, Western livestock, Central cash grain, North-eastern dairy and Eastern livestock. Differences in product prices give differ-

ences in uncertainty between the four product combinations studied. The similar ordering of the four product combinations was hog-beef feeder, hog-dairy, general livestock and cash grain.

The precautionary adjustments in resource use which farmers might adopt were found to be effective in reducing uncertainty. Diversification reduces the uncertainty of income anticipations in livestock production as indicated by the above ordering of four selected product combinations. The uncertainty of cash grain production being low in Iowa probably represents a special case of a very high productivity area in the production of a product with an inelastic demand. Share leasing reduces uncertainty relative to the alternative of low-equity financing. Since these precautionary adjustments in resource use do reduce uncertainty, they can represent rational behavior from the individual viewpoint.

Various agricultural programs which have been proposed or implemented were analysed to determine whether they would be effective in reducing uncertainty, and the inefficiency resulting from individual precautions to uncertainty. Parity pricing reduces the uncertainty associated with cash grain production but increases the uncertainty associated with livestock production. The associated reductions in the level of income are very large. It is generally accepted that most individuals will accept a lower level of income to achieve greater certainty. It would appear that the reduction in the level of income which would have resulted from parity pricing is much larger, relative to corresponding reduction in income variability, than most firms would be willing to accept.

Cost-of-production crop insurance was effective in reducing the uncertainty of crop production but yield insurance had

1 a. Chairman of Committee, Earl O. Heady, Dept. of Economics and Sociology.
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the opposite effect of increasing uncertainty.

Manipulation of the price system is not an effective device by which social action might reduce the uncertainty of production planning in agriculture. Even if such price regulation were of a nature which would remove price uncertainty effectively, it does not remove income uncertainty because of the technical uncertainty of yield. Similarly, yield insurance is not effective in reducing uncertainty because it does not reduce the uncertainty of price. Since adjustments in resource use are undertaken only as a precaution against income uncertainty, any program which proposes to reduce uncertainty must have consistent effect of reducing the variability of net income itself rather than one of the components of net income. To achieve the greatest possible effectiveness in reducing uncertainty, a program should be directed at reducing the probability of occurrence of adverse incomes without materially affecting the level of mean income over time. It is because these two characteristics are incorporated in cost-of-production insurance that such a program can be effective in reducing uncertainty.

An analysis of the effect of a program in reducing uncertainty which accepts income variability as a measure of uncertainty has inherent limitations. It cannot accommodate the component of change in income variability which results from changes in the pattern of resource use in response to

the introduction of the program. If a program is introduced which is effective in reducing the uncertainty associated with the existing pattern of resource use, which is the criterion of effectiveness in this study, the need for precautionary adjustments is reduced. A reduction in the use of precautionary adjustments will give greater efficiency of resource use. The increase in efficiency is in the form of a higher income to the firm since efficiency has been defined by the criterion of profit maximization. Both the form of the stream of income from the reorganized pattern of resource use and the level of income it yields are factors which can define a further reduction in uncertainty. Within some range, then, reducing uncertainty can be an accumulative process and any initial reduction can have a multiplied effect.

This type of analysis cannot measure the effect of any program in reducing the reaction, in terms of precautionary adjustments in resource use, to a given degree of uncertainty. Any program which reduces uncertainty might have this type of effect but modifications of credit availability and general policy directed at the level of employment and income would be most effective in this respect. Alternative methods of analysing the effects of programs of this nature are not available. Although the analysis conducted cannot consider all aspects of the possible programs, it does demonstrate the relative effectiveness of those considered.

ALTERNATIVE METHODS OF OBTAINING ADEQUATE RESOURCES IN THE DEVELOPMENT OF IRRIGATED FARMS¹

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Obtaining control of adequate resources by the settler in the development of a newly irrigated farm presents a complex problem to the settler himself and to the public. Frequently the settler has been forced to quit before he could develop the farm to a point at which it would support the farm operations and supply the family living. The main hypothesis of the study

was that meaningful revisions in the institutional framework within which settlers develop farms are fundamental, and that the solution of the problem will require the use of an accelerated rate of farm development and combinations of several tenure and credit arrangements, of which the usual credit programs and owner-operatorship are two but not exclusive means of action.

This study of resource control and use in irrigated farm development was conducted in the Buffalo Rapids Area in eastern Montana. In this area, several unique and important methods were used

- 1 a. Chairman of Committee, John F. Timmons, Dept. of Economics and Sociology.
b. Doctoral Thesis No. 1231. Submitted December 10, 1951.
- 2 a. B.S., Utah State Agricultural College, Logan, Utah, 1935.
M.S., Iowa State College, Ames, Iowa, 1948.

in clearing and leveling the land, constructing farm irrigation structures, and providing for buildings, livestock, and machinery, which offered experience not previously afforded on reclamation projects. Six groups of farms were delineated on the basis of tenure and the extent of development before the settlers began operation of the farms. The tenure pattern included private owner-operators and tenants, and the sale and lease of public lands to private individual operators. Private owners developed about one-third of the land and buildings were already constructed on these farms. The public agencies predeveloped the remainder of the land including farm irrigation structures on all farms using large-scale equipment and technical assistance, and constructed a set of buildings on about 50 per cent of these farms. A stratified random sample comprised of 74 farm families was drawn from the 6 groups.

The accelerated rate of development, combinations of owner-operatorship and leasing, credit for the purchase of farms with only 5 per cent downpayment, and other unique arrangements satisfactorily served as means for irrigated farm development during the first 10 years of settlement. The accumulation of owned resources within this period of farm occupancy averaged more than \$1,000 per farm each year.

The construction of buildings on a portion of the farms before the settlers took over materially assisted to provide a level of living which was more adequate than the level usually achieved in the early stages of farm development. The farm buildings were conducive to the establishment of livestock enterprises. Credit facilities were particularly lacking for the purchase of livestock and for the construction of buildings on those farms for which buildings were not provided by private landlords and public owners.

From the public point of view, the rapid establishment of crop and livestock production permitted the early utilization of the water supply system which represented a large investment by the public. Further analysis is necessary to ascertain the optimum rates of development in the public interest under various price and demand situations.

The stability of tenure and farm operations was considerably greater than has been achieved on a large proportion of the irrigation projects in the past. The leasing processes in Buffalo Rapids resulted in some movement of settlers be-

tween farms during the first year or two of adjustment but after 10 years of settlement no families had left the area. The reasons for this stability were only partly attributable to a high income period.

Variables other than tenure and the rate and timing of development such as soils, water, asset composition, crop acres, beginning net worth, and length of settlement are also important to successful farm development. On the basis of available data, significant differences and relationships existed only between two of these independent variables—acres irrigated and the length of settlement—and the several dependent variables such as resource accumulation and level of living.

Agriculture has experienced numerous innovations during the first half of the century. Innovations in the institutional field, as related to irrigated farm development, have been tried on only a limited scale. The problem of resource control and use in the development of irrigated farms is still vigorously emphasized but the solution is being attempted largely with the methods that have been unsuccessful in the past. Sufficient attention has not been devoted to alternative lines of action which are available to achieve the desired and desirable ends.

Several positive lines of action can be posed as a result of this study. These constructs involve complex administrative and organizational difficulties that would arise with the introduction of new programs and policies in the development of irrigated farms. Predevelopment and dedevelopment at an accelerated rate might be accomplished under various arrangements including: (1) development by an association of the local settlers, (2) farm developmental leases, (3) public development and resale of the farms, (4) development by private contractors, (5) private development by owner-operators, and (6) private land owners who develop and lease the land. Owner-operatorship supplemented by renting may be preferable to the sole emphasis of owner-operatorship. Emphasis on the operating unit rather than a limitation to the size of ownership may facilitate this process. Improved leasing arrangements are fundamental to this construct of action, especially the determination of ways to encourage farm developmental operations by tenants to the mutual satisfaction of the contracting parties.

In the initial 10 years of most irrigation projects, credit facilities have been virtually non-existent. Alleviation of this credit problem is closely related to the

extent of development at settlement and the rate of development before or after settlement. Rapid development furnishes an income producing base which meets the requirements of credit agencies more adequately than development by the settler at a slow rate. The application to lending of the marginal productivity principle instead of lending a percentage of equity has particular application in a new area where the equity may be extremely small. Credit programs apparently will have to be designed in terms of the improvements and income that would result from lending, rather than from relating loans to the meagre equity in resources held by most settlers. The need for credit initially to acquire land and farms depends on the

extent of farm development at the time of purchase. Lending on a fully developed farm with only a 5 per cent downpayment seems to be working out well in Buffalo Rapids. Variable repayment contracts would probably have been advisable, depending on the income fluctuations during the repayment period.

Constructs of action and subsequent programs cannot be grounded in terms of the great extent of public participation in the Buffalo Rapids Area, especially for the larger areas proposed for development. Private institutions are fundamental to the economy of the United States and the suggested lines of action are applicable to an institutional framework in which private enterprise is the primary segment.

PURINE METABOLISM OF HETEROTROPHIC BACTERIA¹

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Comparatively little is known concerning the mechanism of synthesis or degradation of bacterial purines. The purpose of this investigation was to obtain information pertaining to the synthesis and degradation of purine bases by heterotrophic bacteria, and to correlate the purine metabolism of these organisms with that found in animal tissue.

Prior to this investigation, the fact had been established that certain of the heterotrophic bacteria are not dependent on exogenous purines for nucleic acid synthesis. In addition, it was known that *Aerobacter aerogenes* and *Escherichia coli* could be grown on a medium containing dextrose as the sole source of carbon and ammonium sulfate as the sole source of nitrogen. These facts suggested that information could be obtained concerning the bacterial synthesis of purine bases by these organisms through the application of isotopic procedures involving the addition of labeled compounds to the dextrose ammonium sulfate medium, and the isolation of the purine bases from the cellular nucleic acids formed as the result of growth.

Preliminary to the study of the utilization of various isotopically labeled compounds as possible purine precursors, it was found necessary to establish a procedure for the isolation of the purine bases from bacterial nucleic acids. Adenine and guanine had previously been shown to be present in the nucleic acids of *Aerobacter aerogenes*. An isolation procedure for these bases from the nucleic acids of this organism was devised with sufficient amount of the purine bases being obtained to permit stepwise degradation.

Studies were carried out with carboxyl labeled glycine (C^{13}) and the isotope was found in both the isolated adenine and guanine. The procedure used did not establish the position of the isotope in the bases, nor rule out the possibility of the decarboxylation of the carboxyl labeled glycine and the subsequent incorporation of the label through other pathways. In light of this possibility, glycine was synthesized with the carboxyl carbon labeled and the nitrogen atom of the amino group (N^{15}) also labeled. This compound was added to the culture medium and the isotopes were found incorporated in the purine bases. Stepwise degradation demonstrated that the C^{13} (carboxyl carbon) was in position 4 and the N^{15} from the amino group in position 7 of the purine bases. These results indicate that glycine is directly incorporated as such in the bac-

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terial purine bases and were reported by Sutton, Schlenk, and Werkman (1951). More important, it correlated the findings in *Aerobacter aerogenes* with those of various workers using animal tissue, thus permitting the possible assignment of the findings in tissue to the problem of synthesis of purines by heterotrophic bacteria.

The experimental data obtained with labeled acetate indicate that this compound is not involved in the synthesis of bacterial purine bases. The metabolic origin of position 6 of both the adenine and guanine isolated from the bacterial nucleic acids was found to be carbon dioxide. Of interest is the finding of the isotope (C^{13} from sodium bicarbonate) in positions 4 plus 5 and 2 plus 8. The data obtained indicate that 14.2 per cent of the isotope was present in positions 4 plus 5 and 18 per cent in positions 2 plus 8. These values indicate that carbon dioxide may be involved in the synthesis of glycine, and also reduced to formic acid. Buchanan and Sonne (1946) have shown that formic acid is incorporated in uric acid excreted by pigeons, and in the adenine and guanine from rat liver tissue as reported by Heinrick and Wilson (1950).

Serine was investigated as a possible source of glycine; however, no experimental evidence was found for the pres-

ence of the serine splitting reaction in *Aerobacter aerogenes*. Additional studies indicate that 4(5)-amino-5(4)-imidazole-carboxamide is not a utilizable intermediate in the formation of bacterial purines as suggested by Ravel, Eakin, and Shive (1948).

Studies on the degradation of the purine bases by *Aerobacter aerogenes* and *Escherichia coli* indicate that these compounds are not completely degraded by the mechanism present in animal tissue.

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MOVEMENT OF IRON, MANGANESE, AND TITANIUM IN THE DEVELOPMENT OF LOESS-DERIVED PRAIRIE SOILS¹

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A functional relationship has been established between the soil characteristics and the distance from the loess source of the level and gentle sloping soils in southwestern Iowa. These soils provided an opportunity to study the transformations which iron, manganese, and titanium undergo as a result of the processes which

are operative in the development of these soils. In this investigation, two loess-derived soils formed under prairie, Minden from western Iowa and Edina from southern Iowa, were selected. The former is a slightly weathered Brunigra (Prairie) soil and the latter is a highly weathered Planosol.

Five horizons were selected from the Minden and Edina profiles. Samples from these horizons were fractionated into the following five size fractions: fine clay (less than .2 micron), coarse clay (.2-2 micron), fine silt (2-5 micron), medium silt (5-20 micron), and coarse silt and sand (greater than 20 micron). Total iron, free iron,

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total manganese, and total titanium determinations were made on each of the size fractions. Lattice iron was designated as the difference between the total iron and the free iron as determined by the methods used in the investigation.

It was found that, in general, the total iron content of the various size fractions decreased with increasing particle size. This would seem to indicate that the richer iron-bearing primary minerals in the original loess material were of the smaller sized particles. If this premise is true, the soils at a greater distance from the loess source would have a higher iron content than the soils closer to the source of the loess due to the sorting action of the wind. It is believed that the data presented, although not completely conclusive, indicate that the iron content of the Edina parent material was higher than the iron content of the Minden parent material.

The study of the distribution of iron in the different size fractions of the various horizons of the Minden and Edina soils showed significant changes as a result of the processes of soil formation. It was found that, on weathering, there was a movement of iron to the greater-than-20 micron fraction and to the less-than-2 micron fraction. The former shift was due largely to free iron, while the latter shift was due largely to lattice iron with some movement occurring in the free-iron state. The movement of free iron to the greater-than-20 micron fraction occurred in the lower A and upper B horizons and was probably due to the formation of concretions. The free-iron movement to the fine clay fraction occurred in the lower horizons and was probably responsible for the mottlings and splotches apparent at the lower depths in the Edina profile.

The most conspicuous and probably the most significant iron movement occurred in the Edina profile as evidenced by the large amount of lattice iron found in the fine clay fraction of the B₂ horizon. The movement of iron to the lattice form in the fine clay fraction was not limited to the B₂ horizon but was true for all horizons studied with the exception of the surface, where a larger per cent of the total iron of the surface horizon was found in the fine clay of the Minden than in the fine clay of the Edina.

The accumulation of lattice iron in the fine clay of the Edina was believed to be due to the formation of an iron-bearing secondary clay mineral. In light of the information available it was suggested that nontronite was the clay mineral formed and that it was formed in the lower poorly drained horizons of the Edina profile.

The data for the iron distribution in the Minden profile indicated that some movement of iron had taken place even in this relatively unweathered profile. This indicates that weathering of iron-bearing minerals and subsequent movement of iron in the profile is one of the earlier steps in the genesis of these soils, as it occurred before much textural differentiation was apparent.

A much greater redistribution of total iron and lattice iron occurred in the formation of the Edina soil than in the formation of the Minden soil. The difference in iron accumulation between the Minden and Edina soils is very minor when compared with the differences in iron accumulation between these soils and Podzols and Latosols.

There was a difference in the behavior of iron and manganese on weathering. Manganese showed a movement to the greater-than-20 micron fraction, while the main movement of iron was to the fine clay fraction. It was believed that the movement of manganese to the large fraction and its location in concretions are related to the movement of iron to concretion centers. Further study will have to be carried out before the nature of this relationship can be explained.

Although the titanium content of the whole soil and the various size fractions of the Minden and Edina profiles were fairly constant, the data indicated a different distribution of the total titanium as a result of the processes of soil formation. It was concluded that titanium is not a good indicator element for estimation of age of soils of the type included in this investigation.

The validity of the concept which postulates that the soils of the nature of this study are undergoing podzolization was questioned in light of the information available regarding these soils.

DIFFERENCES IN MILK PRODUCTION AND IN AGE AT FIRST CALVING AMONG INDIAN AND CROSSBRED DAIRY CATTLE IN INDIA¹

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In many tropical areas efforts have been made to synthesize from crosses of Indian and European cattle a group that would be better producers of milk and yet be adapted to tropical conditions. In India some crossbreeding work on these lines was done at the military dairy farms. Purebred Sindhis and purebred Sahiwals were crossed with Holsteins and from these were produced grades containing 2/8, 5/8, 6/8 and 7/8 Holstein blood. The data were examined for differences between the two Indian breeds and their various crosses with the Holsteins. The purpose was to learn which were most suitable for milk production on well managed Indian farms. The data came from the sixteen years beginning in 1922 and ending in 1937. The two traits that were considered in great detail were: (1) age at first calving and (2) production of milk per lactation. Dry period and length of lactation were considered in less detail. The method of least squares was used for estimation and for testing hypotheses.

Age at first calving differed significantly between the various herds and between the various proportions of Holstein blood, the latter differences being the more important. The various proportions of Holstein blood affected age at first calving in a curvilinear way, age being high with no Holstein blood and decreasing at a decreasing rate as the fraction of Holstein blood increased. The crossbreds containing 4/8 or more Holstein blood came into production about seven-tenths of a year earlier than the purebred native cows. The effect of a given proportion of Holstein blood varied somewhat according to whether the crosses were with Sahiwals or Sindhis. There was little average difference between the Sindhis and the Sahiwals in age at first calving.

The production of milk per lactation was affected significantly by the same factors which affected age at first calving and also by length of lactation period, but not significantly by the time of year at which calving occurred. The Sindhi breed was, on the average, better than the Sahiwal in crosses with Holsteins. The proportion of Holstein blood was the most important source of variation for milk production. The effects of various proportions of Holstein blood followed a curvilinear trend, production starting low with no Holstein blood, rising linearly to 5/8 Holstein blood and declining thereafter. The 5/8 Holsteins produced 2522 pounds of milk per lactation more than native cows.

The purebred Indian cows generally had shorter lactation periods and longer dry periods than the crossbreds. About sixty per cent of the 4/8 and the 5/8 Holsteins had dry periods between 55 and 114 days in length, while thirty per cent of their lactations were 300 to 329 days long. Within groups having the same fraction of Holstein blood, the repeatability of the dry periods of the same cow was .08.

Either the genes for early sexual maturity are dominant over those for late sexual maturity or the character has a threshold of expression. This could be due to additive action of genes production and a threshold expression of genes for adaptability to tropical conditions. The threshold seems to lie around the 4/8 level of the Holstein blood. With more than 5/8 Holstein blood, adaptability to tropical conditions declines rapidly.

In general the 5/8 Holstein-3/8 Sinhi combination appears to be the most suitable one for the conditions prevalent in those parts of India where these animals were raised and kept. The reasons for such animals being more suitable than the other pedigree groups are the following:

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- a) They possess early sexual maturity.
- b) They produce more milk per lactation.
- c) They have shorter dry periods and consequently are more regular breeders under tropical conditions.
- d) They tend to have lactations of the desired length.

STALK ROT DEVELOPMENT IN CORN FOLLOWING THE EUROPEAN CORN BORER¹

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The development of stalk rot in corn following the entrance of the European corn borer was investigated (1) by examining the microflora of the rotted tissues in field stalks naturally infested with the insect, (2) by evaluating rot production from microorganisms isolated from these tissues and introduced singly into healthy green stalks, (3) by examining the microflora of rotted tissues resulting from the introduction of these microorganisms into such stalks, and (4) by evaluating rot production in healthy green stalks as a result of introducing a combination of several microorganisms. In addition, the inheritance of rot resistance and a physiological basis for such resistance were investigated.

Bacteria, *Fusarium moniliforme* and *Cephalosporium acremonium* were the most frequent inhabitants of the rotted tissues found in stalks invaded by the European corn borer, while *Gibberella zeae*, *Diplodia zeae*, *Mucor* sp., *Rhizopus* sp. and *Nigrospora oryzae* were less frequent. The three microorganisms in the first group were found in 94, 86 and 43 per cent, respectively, of the 36 stalks examined while the six microorganisms in the second group were found in 23, 14, 11, 9, 6, and 3 per cent, respectively, of these stalks.

When certain of these microorganisms were introduced into internodes of field-growing stalks of inbred line M14 and Iowa hybrid 4316 during 1950 about two weeks after pollination by toothpick and hypodermic needle methods, most rot resulted after about six weeks from *Cephalosporium acremonium*, *Cephalosporium* sp. I in Iowa hybrid 4316, an intermediate amount resulted from *Nigrospora oryzae* and *Mucor* sp. and a smaller amount resulted from *Rhizopus* sp., *Cephalosporium* sp. II, *Fusarium* sp., a yeast and bacteria, which were no different from the amount of rot produced from sterile water or sterile toothpicks. In inbred M14 most rot resulted from

Gibberella zeae and *Rhizopus* sp., while the amount of rot produced from the other microorganisms was about the same as from sterile water and sterile toothpicks. There was no significant difference in the amount of rot between toothpick and hypodermic needle methods of introducing microorganisms into stalks. Higher percentages of the internodal areas were rotted in the inbred line than in the hybrid.

In a comparable trial in 1951 when inbred line L289 and Iowa hybrid 4316 were used, and the stalks were surface disinfected prior to inoculation, most rot developed from *Diplodia zeae* and *Cephalosporium acremonium*, an intermediate amount of rot developed from *Fusarium moniliforme*, *Gibberella zeae* and a yeast, while the least amount developed from bacteria, which amount was no different than from sterile water or sterile toothpicks. There was no difference in the amount of rot between the two kinds of corn or between the two methods of introducing microorganisms into stalks.

The microflora of the rotted tissues in Iowa hybrid 4316 in 1950 included most frequently the microorganisms introduced, bacteria and *Fusarium moniliforme*, and less frequently *Cephalosporium acremonium*, *Diplodia zeae* and *Gibberella zeae*. *Cephalosporium acremonium* and *Diplodia zeae* were found more often than any other organism in the upper and lower nodes of the inoculated internode, indicating that they were systemic within the plant and may have entered at some other place than at the inoculation point.

The microflora of the rotted and adjacently healthy-appearing tissues of inoculated stalks in 1951 were essentially the same as in 1950. Five of seven original inoculants were recovered from most of the stalks one-quarter inch away from the puncture hole, at the lower edge of the rot and at the upper node of the inoculated internode, while they were recovered from fewer stalks one-inch above the node of the inoculated internode. *Diplodia zeae* and *Gibberella zeae*, which were the other two inoculants, were recovered from most of the stalks one-quarter inch away from the inoculation puncture hole, but they

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were recovered less frequently farther away from it. Contaminating microorganisms such as bacteria were present in most of the stalks near the inoculation puncture hole, regardless of the inoculant used, and in fewer stalks farther away from this hole. *Fusarium moniliforme* and *Cephalosporium acremonium* were less frequently present in these stalks near the puncture hole and away from it, and were recovered occasionally from other positions in stalks not inoculated with them. Usually more rot developed when these fungi were present than when only bacteria were present.

Introducing *Diplodia zeae*, *Gibberella zeae* and *Fusarium moniliforme* in simultaneous or sequential combination with one another into Iowa hybrid 4316 resulted in less rot from *Diplodia zeae* when it was accompanied or preceded by *Fusarium moniliforme* or *Cephalosporium acremonium* in inoculation, while a greater amount

of rot resulted from *Fusarium moniliforme* or *Cephalosporium acremonium* when these were accompanied or preceded by *Diplodia zeae* in inoculation.

The inheritance of rot resistance, as determined from inoculation with *Diplodia zeae* of four inbred lines, their first and second generation hybrids and their back crosses proved complex although first generation hybrids between moderately resistant and susceptible inbreds carried resistance that approached the resistant parent while second generation hybrids and back crosses carried resistance that was intermediate between such two parents.

A test of *Diplodia zeae* growth stimulating properties of the aqueous extracts and expressed juices of four inbred lines revealed greater stimulation in a reverse order to the relative rot resistance of the inbred lines and in a direct order to the content of total solids in the juices of these lines.

THE REACTIVITY OF CYCLOPROPANE DERIVATIVES WITH CERTAIN FREE RADICALS¹

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A review of the literature since 1900 revealed that cyclopropane derivatives exhibit olefinic characteristics in a number of ways. It has been shown that cyclopropanes can undergo addition reactions with a number of ionic reagents in a manner exactly analogous to the corresponding ethylene derivatives. Similarly, spectroscopic evidence has been presented which indicates that the three-membered ring can interact with unsaturated substituents when in a conjugated position.

This work was designed to ascertain whether or not the similarities in reactivity between ethylene and cyclopropane derivatives could be observed in reactions with free radicals. The compounds with which we chose to work were cyclopropyl cyanide, cyclopropylmethyl ketone and

phenylcyclopropane. These were particularly convenient not only because of their availability, but also because the reactions of their olefinic analogs, acrylonitrile, vinylmethyl ketone and styrene, respectively, with free radicals have been studied exhaustively.

The free radicals employed were benzoate, acetate, diethylcyanomethyl, triphenylmethyl and polystyryl. Of these, the first three are considered, by the criterion of Mayo and Walling,³ to be electron acceptor radicals, while triphenylmethyl and polystyryl are electron donors.

Cyclopropyl cyanide was unaffected when used as a solvent for the decomposition of benzoyl peroxide, acetyl peroxide and azo-bisdiethylacetonitrile. It caused no change in radical concentration when added to freshly prepared triphenylmethyl radical and it failed to copolymerize or enter into a chain transfer reaction when used as a solvent for styrene polymerization.

The kinetics of styrene polymerization were studied using cyclopropylmethyl ketone as a solvent and a trace of benzoyl

- 1 a. Chairman of Committee, George S. Hammond, Dept. of Chemistry.
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- 2 a. A.B., Middlebury College, Middlebury, Vt., 1948.
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- 3 C. Walling, E. Briggs, K. Wolfstirn, and F. Mayo, *J. Am. Chem. Soc.*, 70, 1537 (1948).

peroxide as an initiator. Acetone was used as a control solvent, and the polymerization was found to proceed at approximately the same rate in the two solvents. Examination of the molecular weight data indicated that the rate of chain transfer was small and essentially the same for both ketones. The infra-red spectra of the polymers were identical to the spectrum of polystyrene prepared by bulk polymerization and showed no carbonyl band. Hence, it can be said that there was no copolymerization or chain transfer.

When the kinetics of the decomposition of benzoyl peroxide in both acetone and cyclopropylmethyl ketone were treated by the method of Bartlett and Nozaki,⁴ it was found that a certain amount of induced decomposition had taken place in each solvent. However, the amount of induced decomposition was small, and there was no indication that attack had taken place at the methyl group.

Decomposition of acetyl peroxide in cyclopropylmethyl ketone yielded a small amount of product other than the original ketone. The infra-red spectrum of the product showed absorption typical of the cyclopropyl group and the carbonyl linkage, so the reaction was considered to have taken at the methyl group.

Decomposition of a large amount of benzoyl peroxide in cyclopropylmethyl ketone yielded what appeared to be a mixture of products, but only the original ketone and benzoic acid were identified completely. The infra-red spectrum of another solid resulting from the reaction will be discussed later.

Phenylcyclopropane, contaminated with a small quantity of β -methylstyrene was heated with benzoyl peroxide and yielded

phenylcyclopropane in a somewhat purer state along with a mixture of solids considered to be mostly polymerized β -methylstyrene. However, further treatment of the same phenylcyclopropane with a larger amount of benzoyl peroxide again produced a small quantity of solid material besides the original hydrocarbon and benzoic acid. The infra-red spectrum of this unknown material was very similar to that of the solid resulting from the decomposition of benzoyl peroxide in cyclopropylmethyl ketone and neither spectrum indicated absorption in the regions typical of cyclopropane. Since the melting point of a mixture of these two solids showed no depression, the compounds were considered to be the same. These data are good evidence that cyclopropanes are insensitive to attack by benzoyl peroxide.

H. C. Brown's⁵ treatment of cyclopropane, using his I-strain theory, as well as the molecular orbital approach of Coulson and Moffitt,⁶ have predicted that hydrogen abstraction from a three-membered ring by free radicals would be, at best, difficult. Our experimental data indicate that no such reaction takes place whatsoever.

Although the energy gained by the cleavage of cyclopropane derivatives may be approximately equal to that gained by addition to the corresponding olefins, ring opening was not observed. It is felt that the difference in the reactivities of the two types of molecules is due, primarily, to the difference in the activation energies for the reactions involved.

4 P. D. Bartlett and K. Nozaki, *Ibid.*, 69, 2299 (1947).

5 H. C. Brown and M. Gernstein, *Ibid.*, 72, 2926 (1950).

6 C. A. Coulson and W. E. Moffitt, *Phil. Mag.*, 40, 1 (1949).

TRANSLOCATION IN SOYBEAN PLANTS¹

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Investigation of the process of translocation in the soybean has been undertaken by means of following the movement of

radioactive substances in the stem following photosynthesis with $C^{14}O_2$. The plants used were soybeans, Hawkeye variety, which were grown in a growth chamber under constant conditions at 800 to 1000 f.c. light intensity. $C^{14}O_2$ was introduced by means of a special apparatus which enclosed the first trifoliate leaf which was fully expanded. The translocation experi-

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ments were timed as beginning at the time of $C^{14}O_2$ introduction, and after the various time periods the leaf and growing tip were severed and the stem cut into sections two cm. in length.

Analysis of the radioactive components of the 80 per cent ethanol extract of the leaf, tip and stem sections was accomplished by means of filter paper chromatography coupled with radioautography of the chromatographs. It was shown that for the time periods investigated (20, 30 and 45 minutes) the leaf contained the following radioactive compounds in the general order of decreasing radioactivity: sucrose, glucose, fructose, glyceric acid, malic acid, glutamic acid, raffinose, alanine, serine, triose, citric acid, succinic acid and aspartic acid. If these sucrose was by far the most radioactive, containing over 50 per cent of the total activity in all cases. Analysis of the tip and stem sections showed the radioactivity primarily in three compounds, sucrose, glucose, and fructose, with sucrose again having the most activity. In sections toward the lower portion of the stem sucrose accounts for over 95 per cent of the total activity in the individual stem section extracts.

The distribution of radioactivity among the alcohol-soluble and insoluble compounds has been made for 20 and 30 minute time periods. The majority of the activity in the insoluble fraction was found to be extractable in perchloric acid, which is indicative of starch. However, all the activity could not be accounted for in the precipitated starch. The remainder of the activity in the insoluble fraction resided in cellulose and proteins.

It was found that the total activity in the various stem sections is a logarithmic function, as is the specific activity of the various sugars. By means of the intercept of the plot of the logarithm of the total activity a rate of translocation of 1.6 cm. per min. was obtained.

In general the curves of the specific activities of glucose and fructose are similar while sucrose is distinct. By means of plotting the ratio of the specific activity of a particular sugar in the leaf to the specific activity of the same sugar in the various stem sections, curves for the three sugars are obtained which are interpreted to show a preference for sucrose translocation. This

preference probably arises in the diffusion of the sugars into the sieve tubes, since the curves for the sugars have the same general slope. Once the sugars enter the sieve tubes they are translocated in a similar manner.

Although the majority of the radioactive translocate moved basipetally from the second foliar node, simultaneous movement into the growing tip took place. Sucrose accounted for the majority of the radioactivity in the tip translocate, fructose and glucose also being radioactive. However, compared to the stem sections, sucrose contained a smaller percentage of the total activity in the tip.

The effect of light upon the translocation process was investigated. Aside from its obvious requirement to form photosynthate, light had no effect upon translocation. Experiments performed at high (7,000 f.c.) and low (60 f.c.) light intensities indicated no difference which could not be explained by increased photosynthesis at high light intensity.

Translocation experiments performed at 29°C. and 0°C. showed a drastically decreased rate of translocation at the lower temperature.

Isolation of a portion of the stem with hot paraffin rings (100°C.) was shown to result in retention of the radioactivity gradient in the isolated portion. Although there was some accumulation above the lower barrier after five hours (indicating a polarity of movement) the stagnation of the main translocation stream was evident.

Application of 2,4-D resulted in increased concentration of free sugars in the leaf and stem one day after application. Notwithstanding this increase the amount of sugar translocated from the leaf was found to be less than normal, which may (over extended periods) so impoverish the root that its normal metabolism is impaired. In small amounts (25 micrograms) 2,4-D increases the rate of translocation. Analysis of the specific activity ratio curves for the plants treated with 2,4-D shows in general decreased slopes and an increase in the intercept values. This suggests that 2,4-D effects a slower rate of diffusion of photosynthate into the sieve tubes, with normal transport occurring after entrance therein. This could explain the lethal effect of 2,4-D upon plants.

ECONOMETRIC ANALYSES OF THE DEMANDS FOR PORK, BEEF, AND POULTRY PRODUCTS¹

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Due to the frequent governmental intervention in controlling agricultural prices during the past three decades, the need for appropriate economic and statistical tools guiding the agricultural policy makers has been accentuated through time. This study is designed for the purpose of investigating some statistical methods of estimation combined with economic theory in search for the best estimates of demand elasticities. The specific problem is that of dealing with the estimation of the structural parameters of the demands for three agricultural commodities: pork, beef, and poultry products.

Economic theory, being a rich source providing us with assumptions and stimulating our introspective judgment, is used as a starting point in our investigation. Viewing the economic system as a set of inseparable relations functioning simultaneously characterizes the economic approach of this study. The theory of demand, as well as the theory of supply is, thus, presented as the economic foundation of the problem.

In dealing with the problem of economic measurement, constructing an econometric model, consistent with our *a priori* knowledge and assumptions and containing relevant economic relations, is the first logical step of our investigation. The model constructed for this study is of a shock type, i.e., errors in equations and not in measurements are considered. The model consists of thirteen linear (in logarithms) stochastic equations: six demand equations (of which three were selected for estimation, one for pork, one for beef, and one for poultry products), six supply equations, and one production equation.

Considering a certain economic behavior as a product of many economic relations operating simultaneously calls for the adoption of the method of multiple equations in our statistical estimation. The

observable variables included in the model are classified under two groups: "jointly dependent" variables, the formation of which is to be explained by the system, and "predetermined" variables which are determined outside of the system. The non-observable variables are called "latent" variables or "disturbances" and they represent the shifts of the considered function caused by variables not included in the model.

Prior to the process of estimation, the selected equations have to be tested for identifiability. The identification problem arises with (1) economic estimation and (2) dealing with more than one relation simultaneously. Formal definitions and discussion of identification are presented in the text. A necessary condition and a sufficient condition for just-identifiability and over-identifiability based upon the knowledge of the rank of matrices of the structural parameters are stated without a mathematical proof.

Estimation is the final step in the problem of economic measurement. The outcomes of all the previous stages of analysis subjected to the prevailing physical limitations determine the method of estimation to be used. Two methods of estimating the structural parameters of a single equation in a complete system of linear stochastic equations are presented. One method deals with the estimation of an over-identified equation, i.e., when the number of predetermined variables appearing in the system, but not in the selected equation, is equal to or greater than the number of jointly dependent variables appearing in the selected equation. This method is conventionally called the "limited-information" method. The other method deals with the estimation of a just-identified equation, i.e., when the number of predetermined variables appearing in the system, but not in the selected equation, is one less than the number of jointly dependent variables appearing in the selected equation. Both methods lead to the estimation of the structural parameters of the selected equation through the reduced-form equations. The process of transform-

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ing the estimates of the reduced-form parameters to estimates of the structural parameters is much more complicated in the former method (the limited-information method) than it is in the latter.

The model constructed for this study is finally carried through the empirical stage of analysis. Data, representing the included variables, were obtained for the interwar period, 1921 to 1941 inclusive. Indices of prices and income are deflated by the cost-of-living index. Quantities are computed on a per capita basis. In all cases, averages for the United States as a whole, being our investigated market area, are computed. Government bureaus' publications are the sources of the data used. Some series are, however, derived to adapt the definitions of the corresponding variables.

By testing the identifiability of the three selected equations in the model (applying the necessary condition only), it is found that each equation is over-identified by one predetermined variable. The limited-information method is, hence, applied to the estimation of the structural parameters of the three selected equations. Due to some technical and physical difficulties, rather unrealistic estimates are obtained. By modifying the model slightly, each of the three selected equations becomes just-identified. Estimates of the structural parameters of the three equations are obtained by using the method applicable to the case of just-identification. Since the data originally used are in forms of logarithms, the estimates obtained represent the elasticities of the three demand equations. A test of auto-correlation of the error terms is made for the pork, beef, and poultry-product over-identified and just-identified structural equations. The same test is made for the reduced-form-regression equations of the just-identified as well

as the over-identified model. The results show that the error terms in all the tested equations are likely to be random (in the probability sense).

For purposes of comparison and investigation, a general discussion of the single-equation versus multiple-equation models is presented. Multicollinearity as a major obstacle to economic measurement by multiple-equation techniques is discussed. Although its existence causes the obtainment of unrealistic elasticities in a single-equation model, yet it may not affect the predictive power of the equation. Three single-least-square-equation models representing the demands for pork, beef, and poultry products are constructed and estimated. Tests of the significance of the estimates, at the two levels of probability, are performed. A table containing the two sets of estimates of elasticities obtained by multiple-equation method and single-equation method shows a considerable, but expected, difference between the two sets.

The problem of prediction under the assumption of unchanged structure and after the structural changes have taken place is briefly discussed. Using the estimates of the single-least-square equations (regression coefficients) and the estimates of the multiple equations (structural coefficients), prediction of the quantities demanded for pork, beef, and poultry products for the years 1947 and 1948 is made (under the assumption of unchanged structure). Except for poultry-product case, the single-least-square equations show a higher prediction power than do the multiple equations. This result does not necessarily favor the adoption of the single-equation method since, except in a special case, the problem of structural estimation is not the same as the problem of predictive estimation.

SOME EFFECTS OF ORGANIC FUNGICIDES ON THE GERMINATION AND RESPIRATION OF *MYROTHECIUM VERRUCARIA*¹

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Department of Botany and Plant Pathology

This investigation was undertaken to study the relationships between the sensitivities of growth and of respiration of the fungus *Myrothecium verrucaria* in its responses to a selected group of organic fungicides. The inhibitory effects of these toxicants on spore germination and on spore and mycelial respiration were compared by means of LD50 and slope values from dosage-response curves.

The toxicants included p-benzoquinone, 2,3-dichloro-1,4-naphthoquinone, tetrachloro-p-benzoquinone, ethyl mercury chloride, pentachlorophenol, 2,4-dinitrophenol, tetramethylthiuram disulphide, disodium ethylenebisdithiocarbamate, and actidione. All of them were tested in true solutions so that the toxicant concentration was accurately known. This is in contrast to the usual practice of testing fungicides with low water-solubilities in suspensions or in dried deposits for germination tests.

Suitable culture conditions for the production of spores and of mycelium were determined for this study. Examination of the physiological properties of spores showed that (1) sporulation occurred within 4 days on appropriate culture media, (2) spores germinated completely (100 per cent) in 4 to 5 hours when glucose and yeast extract were included in the nutrient medium, (3) the Q_{O_2} was about 80, and (4) respiratory quotient was about one. A similar examination of mycelium showed that the growth period for maximum Q_{O_2} with a suitable inoculum was 24 hours, (2) the Q_{O_2} was about 60, (3) the respiratory quotient was somewhat greater than one for 24-hour mycelium, (4) increased O_2 tension had no effect on

the rate of respiration of 24-hour mycelium but did increase the rate of 48-hour mycelium, and (5) there was no anaerobic production of CO_2 . These findings were similar in most respects to those reported for *Myrothecium verrucaria* by investigators at the Quartermaster General Laboratories.

The toxicity of these fungicides in slide-germination tests ranged from 1.8 to 87 p.p.m. excluding 2,3-dichloro-1,4-naphthoquinone and tetrachloro-p-benzoquinone where the absolute concentrations were not determined. The slopes were all steep, between 0.74 and 0.88, and the curves were linear throughout the usable inhibition range. The order of toxicity in the germination tests was the same in spore respiration tests except for actidione. In general, the LD50 values for spore respiration were higher and the slopes were lower than for germination. Actidione was exceptional in being more toxic to respiration than to germination.

The dosage-response curves for the inhibition of spore respiration were, in most cases, non-linear. At high concentrations pentachlorophenol, 2,4-dinitrophenol, disodium ethylenebisdithiocarbamate, and actidione curves levelled off at maximum inhibitions between 85 and 94 per cent. Furthermore, the curves were affected by changes in the toxicity of compounds with time of exposure. Increased inhibition with time occurred with disodium ethylenebisdithiocarbamate and ethyl mercury chloride, and with actidione at high concentrations. Recovery of the spore respiration was pronounced with low concentrations of actidione, pentachlorophenol, 2,4-dinitrophenol, and with all concentrations of tetramethylthiuram disulphide that could be obtained in solution.

The dosage-response curves for inhibition of mycelial respiration were similar to those for spores. The LD50 values for mycelial respiration were higher than for spores except for the two phenols.

The characteristic of maximum inhibition levels of respiration exhibited by several of the compounds suggests that one or more

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pathways of respiratory metabolism may be insensitive to the inhibiting effects of these toxicants. Increasing inhibition with time of exposure, particularly with spores, is possibly due to slower penetration. De-

creasing inhibition with time of exposure has been shown for actidione to be related in part to the decreasing sensitivity of the germinating spores and, in part, to the detoxication of the compound.

ROLE OF TRIPLE COLLISIONS IN EXCITATION OF MOLECULAR VIBRATIONS¹

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The excitation of molecular vibrations is generally believed to be brought about by intermolecular collisions. There exists considerable experimental evidence that for collisions between molecules of the same species, double collisions are principally responsible for vibrational excitation. The collision types responsible for vibrational excitation when molecules of two different species interact have not been systematically studied. Recent experimental evidence points to the possible participation of AAB triple collisions in the vibrational excitation of carbonyl sulphide molecules by argon and by nitrogen molecules.

The purpose of the current investigation was to compare the roles of AB double collisions and AAB and ABB triple collisions in the vibrational excitation of nitrous oxide molecules by helium, nitrogen and argon molecules. Vibrational relaxation times in binary mixtures of the above gases were determined from ultrasonic velocity measurements. The technique of acoustic interferometry was employed to measure sonic velocities at frequencies of 300, 600 and 1000 kilocycles per second. Nitrous oxide was the A type gas. Concentrations of 10.0, 20.0, 30.0 and 50.0 per cent of each of the three B type gases were used. Relaxation times were determined with an accuracy of roughly 5 per cent by these measurements. The dependence of the relaxation times on the concentrations of B type molecules determined the respective roles played by AB, AAB and ABB collisions in exciting the vibrations of nitrous oxide. This study constituted the first known attempt to determine relaxation times in mixtures

containing high concentrations of B molecules from ultrasonic velocity measurements.

It was found that AB double collisions are principally responsible for the excitation of nitrous oxide by helium. AAB and ABB triple collisions play no observable role. Interpretation of the data for nitrous oxide—nitrogen and nitrous oxide—argon mixtures was very difficult, because the catalytic effects of argon and nitrogen are very small. The results indicate that AB double collisions are principally important when nitrogen is the B type molecule. It was not possible to reach any conclusions concerning the behavior of argon.

The relaxation time measured in pure nitrous oxide at a pressure of 1 atmosphere was 0.93×10^{-9} second. This is in excellent agreement with the value reported by one group of investigators, and it is in serious disagreement with that reported by another. The dependence of this relaxation time on pressure indicated that AA double collisions are principally responsible for vibrational excitation in the pure gas. No effect due to AAA triple collisions was observed.

The results also indicate that a formula proposed by Eucken and Aybar³ to describe the relation between relaxation times and the amount of gas B present is not generally applicable to mixtures in which high concentrations of B molecules are used.

The velocity measurements were made with the new Iowa State ultrasonic interferometer. This instrument is described in some detail.

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1 a. Chairman of Committee, Sam Legvold, Dept. of Physics.

b. Doctoral Thesis No. 1298. Submitted June 9, 1952.

2 a. B.S., Iowa State College, Ames, Iowa, 1943.

b. Assistant, Engineering Experiment Station.

3 Eucken, A. and Aybar, S. 1940. Die Stossanregung intramolekularer Schwingungen in Gasen und Gasmischungen. VI. Schallabsorptionen und Dispersionsmessungen an CH_4 , COS und ihren Mischungen mit Zusatzgasen. Zeitschrift für Physikalische Chemie, Abt. B, 46: 195-211.

OIL IMPREGNATION OF DOUGLAS FIR USING A PRESSURE REDUCTION AND AN OIL-WATER TREATMENT¹

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Two methods of injecting a 5 per cent solution of pentachlorophenol into Douglas fir poles to improve the penetration and produce an oil-free surface were developed on a laboratory scale. Commercial scale tests were run to evaluate these treatments.

In both methods of treatment the wood was surrounded with oil at atmospheric pressure and then the pressure was increased to 150 psi to force the oil into the wood. In the "oil-water" treatment, water was injected after the oil period, then the poles were steamed and a vacuum was applied to vaporize the injected water. The laboratory experiments showed that the penetration was improved if the oil to water change was made at the oil treating pressure and if the water period was extended to 6 hours. Raising the water pressure increased the penetration, but lowering the pressure produced a less oily surface. In the "pressure reduction" treatment a high initial oil pressure was slowly reduced to atmospheric, and the wood was then given a steaming and vacuum cycle.

To evaluate the experimentally developed treatments, five commercial scale charges were treated: one by the conventional Lowry method³ to act as a control; three by the oil-water method; and one by the pressure reduction method.

The pressure reduction charge received a retention of less than 5 lb. of oil per cu. ft. of pole and the other charges received an average retention of 6 to 7 lb. of oil per cu. ft. of pole.

Heartwood penetration occurred in a large number of oil-water treated poles but in none of the poles treated by the conventional or reduced pressure processes.

In poles having sapwood depths of from $\frac{3}{4}$ to $1\frac{1}{4}$ inches, the average per cent of sapwood penetrated at the incised groundline was 92 in the control charge, 100 for an average of the oil-water charges, and 93 in the pressure reduction charge. At the non-incised midpoint, the average penetration was 87 per cent in the control, 92 per cent in the oil-water treatments, and 73 per cent in the pressure reduction treatment. The increase in penetration due to incising was up to three times greater for the pressure reduction and oil-water charges than for the control. All treatments produced poles without oily surfaces.

The concentration of pentachlorophenol in the first half inch in the oil-water and pressure reduction charges was greater in the incised groundline than in the non-incised midpoint; the reverse was true in the control charge. The pentachlorophenol concentration deep in the incised wood was greater in the oil-water charges than in the control charge.

The coefficient of variation of the retention on a sapwood volume basis was found to be about 30 per cent and appeared to be independent of the method of treatment, but the coefficient of variation on a pole volume or surface area basis was about 22 per cent for the control and ranged from 24 to 43 per cent for the oil-water and pressure reduction charges.

The oil-water treatment appears preferable to the pressure reduction treatment but, because the data from the latter on a commercial scale were insufficient, no valid comparison can be made. It is believed that the improvements resulting from the oil-water and pressure reduction treatments warrant their slight additional cost, but this cannot be definitely concluded until the service lives of the poles are known.

Continued commercial scale testing of the oil-water and pressure reduction treatments on a semi-commercial basis is recommended.

During the laboratory scale experiments, a theory of liquid flow through wood was evolved; that air is trapped within the treated wood and that the degree of com-

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3 In which the cylinder is filled with oil at atmospheric pressure, the pressure is increased to inject an excess of oil, then the poles are given a vacuum to recover the excess oil, and then steamed.

pression of this trapped air controls the volume and distribution of oil that may be injected. From this theory the general effects of treating conditions on the penetration and on the accumulation of an oil layer on the pole surface can be predicted. The theory also postulates that an increase in retention of 2 lb. of oil per cu. ft. of wood between a 6 and 8 lb. retention

will cause a greater increase in penetration than between a 2 and a 4 lb. retention. It predicts that for a given amount of injected oil, lower treating pressures and higher temperatures tend to increase penetrations and to retard the accumulation of surface oil. It also predicts that the use of a vacuum reduces the potential depth of penetration.

MANGANESE (II), (III), (IV) EQUILIBRIUM IN IODIC ACID¹

GLENN R. WATERBURY²

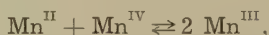
Department of Chemistry

An equilibrium reaction between manganese(II), manganese(III), and manganese(IV) in the presence of agents which form complexes with the tervalent state has been postulated by several investigators. Due to recent interest in the mechanism and analytical use of the periodate oxidation of manganese(II) to permanganate, iodate ion has become one of the more important complexing agents. However, no studies of the equilibrium in a system containing iodate have been reported previously. The determination of the equilibrium constant, the rapidity of the establishment of the equilibrium, and the factors influencing the reaction are the subjects of this work.

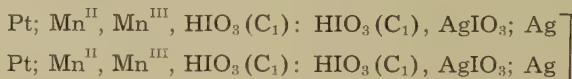
The differences in the light absorption

tions and taking initial readings. Therefore, the equilibrium was demonstrated to be rapidly established.

Colorimetric analyses indicated a large equilibrium constant for the reaction,



but the precision of this method was insufficient to obtain quantitative results due to the low concentration of the manganese(II) or manganese(IV) in the equilibrium mixtures. A potentiometric titration method was developed which provided the equilibrium constants. Potential measurements were made using a Beckman model G pH meter and a double cell of the following description.



characteristics of the three manganese oxidation states permitted colorimetric analyses of each species. The Cary recording spectrophotometer available for this work made possible the determination of any change in the concentration of the manganese(III) formed when solutions of manganese(II) and manganese(IV) were mixed rapidly. No change in absorption was detected after the ten to fifteen second interval required for mixing of the solu-

The total concentration of the manganese was low compared to that of the acid, C_1 ; therefore the liquid junction for this cell was very small.

The general method adopted was to titrate manganese(II) solutions in iodic acid with colorimetrically analysed solutions of manganese(IV) containing small amounts of manganese(III); pure manganese(IV) solutions in iodic acid could not be prepared. All solutions used in any one titration had the same iodic acid, perchloric acid, and lithium perchlorate concentrations. The best value for the equilibrium constant, K_e , was obtained by matching calculated curves for various K_e values to the experimental curves.

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The variables studied were the temperature, iodate ion concentration, hydrogen ion concentration, and the ionic strength. The temperature range used in the experiments was 0°C. to 65°C. with iodic acid concentrations of 0.249 to 1.782 M. The equilibrium constant decreased with increasing temperature and decreasing iodic acid concentration. In experiments to determine the effect of iodate ion and hydrogen ion concentrations, the ionic strength

From observations during electrolysis, it was concluded that the species of the manganese(III) and manganese(IV) oxidation states were negatively charged. The experimental evidence suggested that the predominant manganese(IV) iodate complex was probably hydrolyzed and contained one oxide, one hydroxide, and four iodate ions. If the predominant manganese(III) iodate complex was not hydrolyzed, the most likely overall reaction was:



was maintained at 2 M using perchloric acid and lithium perchlorate. From these studies, the following reaction was shown to best describe the equilibrium reaction:

An approximate value of 2.5×10^{12} at 0°C. was obtained for the thermodynamic equilibrium constant. ΔH° for the reaction was calculated to be -11 kcal.



APPLICATIONS OF VOLTERRA'S THEORY OF COMPOSITION TO HYPERGEOMETRIC FUNCTIONS¹

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The theory of composition developed by Volterra³ can be used to derive many useful properties for some of the important functions which occur in the mathematical literature. In this paper this theory is applied to the study of the hypergeometric series ${}_nF_q(a_1, \dots, a_p; b_1, \dots, b_q; z)$.

The product by composition of the first kind of two functions $f(x,y)$ and $g(x,y)$ is defined as

$$\int_x^y f(x,t) g(t,y) dt$$

and is denoted by f^*g . Here f and g are assumed to be such that the above integral exists. If f is composed with itself, the resulting function $f^*f = f^{*2}$ is called the square by composition of f ; and in general the function $f^{*n} = f^{*n-1} * f$, n an integer ≥ 2 , is called the n th power by composition of f .

Volterra has shown in the theory of com-

position that integral addition theorems can be obtained from algebraic addition formulas. He accomplished this by means of the isomorphism that exists between algebraic formulas which involve only addition and multiplication and those obtained from the algebraic formulas by replacing positive integral powers of the variable by the same powers by composition of a function $f(x,y)$. These new functions are known as the Volterra transforms of the original functions.

Volterra defined a transcendental function⁴ which satisfies an integral addition theorem corresponding to the algebraic addition formula of $e^{az} - 1$. In this present paper there is defined a Tchebycheff transcendental which analogous to the Volterra transcendental satisfies certain integral addition theorems. These integral addition theorems for this transcendental function are derived on the basis of the algebraic addition formula of the Tchebycheff polynomials

$$2T_n(x) T_m(x) = T_{n+m}(x) + T_{n-m}(x)$$

where $T_n(x) = \cos(n \arccos x)$, $n = 0, 1, 2, \dots$. Certain hypergeometric functions such as Bessel functions and Laguerre polynomials are shown to be expressible

- 1 a. Chairman of Committee, H. P. Thielman, Dept. of Mathematics.
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- 2 a. A.B., Bethel College, North Newton, Kan., 1947.
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- 3 Volterra, Vito. *Fonctions de lignes*. Paris, Gauthier-Villars. 1913.

in terms of the Tchebycheff transcendental. On this basis integral addition theorems are derived for these functions.

A typical theorem of this type is the following.

Theorem. For $n \neq 0$, $m \neq 0$, $v > 0$, $r > 0$, $u > 0$,

$$\begin{aligned} 2nm \int_x^y \sum_{i=0}^n \frac{\Gamma(n+1)(-1)^i}{\Gamma(n-1+1)\Gamma(\frac{n}{2}+1)1!} \left(\frac{t-x}{a}\right)^{\frac{u+1r-1}{2}} J_{u+1r-1}[2\sqrt{a(t-x)}] \\ \cdot \sum_{j=0}^m \frac{\Gamma(m+1)(-1)^j}{\Gamma(m-j+1)\Gamma(\frac{m}{2}+j)j!} \left(\frac{y-t}{b}\right)^{\frac{v+1r-1}{2}} J_{v+1r-1}[2\sqrt{b(y-t)}] dt \\ = \sum_{i=0}^{n+m} \frac{\Gamma(n+m+1)(n+m)(-1)^i}{\Gamma(n+m-1+1)\Gamma(\frac{n+m}{2}+1)1!} \left(\frac{y-x}{a+b}\right)^{\frac{u+1r+v-1}{2}} J_{u+1r+v-1}[2\sqrt{(a+b)(y-x)}] \\ + \sum_{i=0}^{n-m} \frac{\Gamma(n-m+1)(n-m)(-1)^i}{\Gamma(n-m-1+1)\Gamma(\frac{n-m}{2}+1)1!} \left(\frac{y-x}{a+b}\right)^{\frac{u+1r+v-1}{2}} J_{u+1r+v-1}[2\sqrt{(a+b)(y-x)}]. \end{aligned}$$

This theorem is a generalization of results found in the literature.⁴

Other results obtained in this thesis deal with the evaluation of some integrals and the series expansions of hypergeometric functions.

One section is devoted to the derivation of identities involving Tchebycheff polynomials. These are used in the sequel to

establish certain relations among hypergeometric functions which are the Volterra transforms of $z^p T_n(1-2z)$, $p > 0$. In this section, use is made of the commutative property of the Tchebycheff

polynomials.⁵ Also, a closed expression for infinite sums involving triple products of Tchebycheff polynomials is obtained. A similar result for Legendre polynomials has been given by Vinti.⁷

A generalized product by composition of $f(x,y)$ and $g(x,y)$ has been defined previously⁸ as

$$f * g = \int_a^b \frac{b(y)}{a(x)} f(x, t) g(t, y) dt,$$

where $f(x,y)$ and $g(x,y)$ are restricted so that the above integral exists. As a side result of this thesis it is shown that if $a(x)$ and $b(y)$ are assumed to be analytic then the associative law $(f * g) * h = f * (g * h)$ will be satisfied if, and only if, either $a(x) = x$ and $b(y) = y$ or $a(x) = c$ and $b(y) = d$, where c and d are constants.

⁴ *Ibid.* P. 159.

⁵ Hadamard, J. Sur un probleme mixte aux dérivées partielles. Bull. Soc. Math. France. 31:208-224. 1903.

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⁷ Vinti, J. P. Note on a series of products of three Legendre polynomials. Proc. Am. Math. Soc. 2:19-24. 1951.

⁸ Davis, H. T. Linear operators. Bloomington, Ind., The Principia Press. 1936. P. 160.

FUNCTION OF BIOTIN IN BACTERIAL METABOLISM¹

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Biotin has been found to stimulate the growth of *Micrococcus lysodeikticus*. The organism will produce only limited growth in the absence of this vitamin. When the bacterium is grown in the presence of both aspartic and oleic acids, biotin is not necessary.

Lysed or acetone-treated *M. lysodeikticus* readily fixes carbon dioxide in oxalacetic acid as determined by exchange reactions utilizing heavy carbon (C^{14}) as a tracer. In the presence of avidin, which specifically binds biotin, little or no assimilation of carbon dioxide can be detected. The addition of biotin to compensate for that inactivated by avidin results in a return to a normal amount of fixation. This indicates a function for biotin as a coenzyme in the Wood-Werkman reaction.

Further evidence that this reaction is a specific metabolic site for biotin activity has been obtained with cells deficient in biotin. Cells grown on a medium consisting of charcoal-treated peptone and yeast extract, inorganic salts, dextrose, a purine-pyrimidine solution, oleic acid, aspartic acid, agar, and a vitamin solution containing no biotin are markedly decreased in biotin content. These cells fail to synthesize aspartic acid, formed from oxalacetic acid by transamination, when incubated in the presence of pyruvate and bicarbonate. The addition of biotin to the reaction mixture, however, results in the immediate formation of the amino acid.

When the formation of aspartic acid is plotted as a function of time, no lag period in the synthesis of the amino acid is demonstrable upon the addition of biotin to cells deficient in the vitamin. This fact indicates that biotin functions in a direct manner characteristic of a coenzyme, rather than indirectly, such as in the synthesis of the coenzyme.

Oxalacetic decarboxylase has been obtained from *M. lysodeikticus* in partially purified form. The method of purification involves treatment of a cell suspension with lysozyme to free cellular material, fractionation of the resulting solution with ammonium sulfate and hydrochloric acid, dialysis, and adsorption of the enzyme on alumina C γ . The procedure results in an approximate 100-fold increase in activity. The enzyme rapidly decarboxylates oxalacetic acid; only manganese ions are required for its activation.

No direct connection exists between biotin and this enzyme. The addition of the vitamin fails to stimulate the decarboxylation of oxalacetic acid. The addition of avidin, to bind any possible biotin left in the preparation, has no effect upon its activity. Biological assay for biotin present in the enzyme, as it is carried through the various steps of purification, reveals no correlation of biotin content and enzymatic activity, such as would be expected if the enzyme was the site of biotin action.

Confirmation of this lack of a direct relationship between biotin and oxalacetic decarboxylase is afforded by experiments with biotin-deficient cells. No differences in the ability to decarboxylate oxalacetic acid is apparent in cells containing normal amounts of biotin and those low in the vitamin. This lack of any difference in enzymatic activity indicates that biotin does not function in the synthesis of the enzyme. The addition of biotin to these cells fails to affect in any way their ability to decarboxylate oxalacetic acid. The possibility that the activity of the enzyme may be dependent upon small amounts of residual biotin present is eliminated, since avidin, which would bind any of the vitamin, does not inhibit the reaction.

The purified enzyme fails to fix carbon dioxide in oxalacetic acid even in the presence of biotin, adenosine triphosphate, or a combination of the two. The evidence indicates that oxalacetic decarboxylase is either not the enzyme carrying out fixation of carbon dioxide or, more probably, is only part of the enzyme system involved.

- 1 a. Chairman of Committee, C. H. Werkman, Dept. of Bacteriology.
b. Doctoral Thesis No. 1250. Submitted March 6, 1952.
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CROP VARIETY RESPONSE TO EXOGENOUS GROWTH REGULATORS II. INHERITANCE OF DIFFERENTIAL RESPONSE IN CORN AND OATS¹

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The common acceptance and increased use of growth regulators in weed control practices emphasize the need for more information regarding differential varietal reaction and tolerance to treatment. This study was divided into two more or less distinct phases; first, that concerning differential response of oat varieties to 2,4-dichlorophenoxyacetic acid (2,4-D) and isopropyl-N-phenylcarbamate (IPC) and the effects of these chemicals upon the various components of yield at several stages of growth; second, that concerning the nature of inheritance of differential response of maize as measured by suppression of root growth by 2,4-D.

In a study of varietal response, 13 oat varieties were tested in the field in 1950 with one-half and one pound per acre butyl ester of 2,4-D and two and four pounds per acre of IPC. Applications were made at three dates during the period of floral primordia initiation and at anthesis. A diagnostic examination of the shoot apices was made on each variety to determine the morphological stage of development at time of treatment during the early period of growth.

Data on yield and the various components of yield were taken, including number of spikelets per panicle and number of kernels per spikelet. In 1951 the same 13 varieties were tested with one pound per acre of 2,4-D at the same periods of development. Similar techniques were employed and data collected as in the previous year. In 1951 two varieties which appeared to show differences in the 1950 test were treated with one pound per acre of 2,4-D at three- to four-day intervals from the 3-leaf stage through heading to study the effects of stage of growth on varietal response. Growing points were examined as in the other test and data on

agronomic characters and components of yield were recorded. Three varieties were selected from the 1950 test for further evaluation with IPC. The varieties were treated with two and four pounds per acre of IPC at four stages near anthesis at five-day intervals to study the relationship of stage of growth to susceptibility with IPC.

In 1950 and 1951 all treatments, regardless of chemical, rate, or stage of growth, reduced yields as compared to the check. Yield reduction by 2,4-D was greatest from treatment at a period during initiation of floral primordia. In general, yield reductions varied directly with rate of application of 2,4-D.

Differential varietal response to 2,4-D at the three early stages of growth was noted among 13 oat varieties. Mindo and Cherokee were considerably more susceptible than Andrew and Shelby. Other varieties were intermediate in response or gave inconsistent results among stages or between years.

Reduction of kernels per spikelet and spikelets per panicle was closely associated with yield. Spikelet number was reduced by treatment with 2,4-D during floral primordia initiation to the greatest extent at the second stage; kernel number was reduced most by treatment four days later. In 1951 the same trend was observed in Mindo and Shelby varieties. However, spikelets per panicle were reduced more than kernels per spikelet by nearly all treatments in Andrew and Cherokee when treated at three-day intervals from the 2-leaf stage to heading.

Examination of shoot apices in 1950 indicated that, considering the average of the 13 varieties, the greatest reduction in spikelet number occurred when branch initials were in process of differentiation and greatest reduction of kernel number occurred when all varieties had terminal floret primordia differentiated and most varieties had additional spikelets differentiated. Within one treatment date, there was among varieties an association between the development of the growing point and reduction in kernel number and yield. It

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was suggested that differential response of varieties noted at any one treatment time may be due to different degrees of development.

Differential yield response between Andrew and Cherokee could not be explained by differences in degree of development in either 1950 or 1951 although Cherokee had greater reduction in spikelet and kernel number than Andrew at stages when differential response was noted.

Reduction in yields obtained from treatment with IPC in the early stages of growth was variable and thought to result from contamination of the soil with the IPC spray material. Treatment at anthesis caused the greatest reduction in yield and was directly associated with reduction of kernel number. Treatment with IPC formulations used was severe on plant tissue and interfered with normal fertilization and seed development. Varietal differences obtained with IPC application were considered random variations.

Laboratory root suppression studies were made to determine the nature of inheritance of root growth inhibition of maize by 2,4-D. Four F_3 and two BC_1S_1 populations from crosses among two tolerant and two susceptible lines were grown in critical concentrations of 2,4-D. With similar techniques, reciprocal crosses among all combinations of nine inbred lines also were tested.

Susceptibility of inhibition of root growth to 2,4-D showed partial dominance over tolerance in some crosses between inbred lines of maize. The distribution of F_3 and BC_1S_1 lines indicated that multiple factors are involved in conditioning inhibition of root growth by 2,4-D; however, transgressive segregation in F_3 lines and shifting of mean response in backcross populations indicated that parents differed by relatively few genes. Studies with reciprocal crosses indicated that maternal effect was of little importance in determining the relative response of root growth to 2,4-D.

THE CONTRIBUTION OF SUBSTRATE STRUCTURE TO ENZYMIC PEPTIDE BOND SYNTHESIS¹

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The effects of variation of substrate structure on the relative extents of the papain- and ficin-catalyzed syntheses of a number of benzoylated amino acid anilides have been studied. Among the naturally and unnaturally occurring amino acids investigated were the benzoyl derivatives of glycine, alanine, valine, leucine, α -amino-n-butyric acid, norvaline, norleucine, α -aminoheptylic acid, α -aminocaprylic acid, α -amino pelargonic acid, S-benzoylpenicillamine, isoleucine and aminoisobutyric acid. It has been shown that the previously observed greater reactivity of benzoylleucine than of benzoylvaline in the papain-catalyzed synthesis of anilides is in accord with steric hindrance by the branching methyl in the valine substrate. This explanation invokes the

principle of steric hindrance in enzyme-substrate interaction involving L-type substrates. The theoretical inferences of this sort of result have been indicated.

The relative rankings of the thirteen benzamino acids in the above reactions were shown to differ when ficin was the catalyst, from the results obtained with papain. The effect of the position of the methyl substituent, however, again dominated in the contrast between leucine and valine.

The relationships of yield to dilution of enzyme have been found to vary both with each of the enzymes and with the substrate.

The papain- and ficin-catalyzed syntheses of peptide bonds with a variety of benzoylated amino acids and glycylanilide in citrate buffer have been studied. Eighteen different benzoyl derivatives of amino acids were used. Coupling and transamidation reactions of the following types were observed:

1. Coupling

Benzoylamino acid + glycylanilide \rightarrow

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Benzoyl- α -aminoacylglycinanilide

2. Transamidation

Benzoylamino acid + glycinanilide \rightarrow
Benzoylamino acid anilide.

The type of reaction which occurred seemed to depend, at least in part, upon the nature of the benzoylated amino acid employed. In some instances, the variation of yield of anilide with pH was also studied. Evidence was presented that the transamidation reactions proceeded via the unreported amine transfer mechanism. Evidence was also presented against invocation of a cosubstrate mechanism where transamidation was observed.

The above studies were extended to include papain-catalyzed reactions which involved alaninanilide, leucinanilide and valinanilide. Again, coupling and transamidation reactions were observed. These results showed that the type of reaction which occurred depends not only upon the nature of the benzoylamino acid, but also upon the nature of the amino acid anilide employed. The transamidation reactions observed with alaninanilide as the substrate followed the steric hindrance concept, invoked above, for the coupling reactions of benzoylamino acids and aniline.

The papain- and ficin-catalyzed reaction of several glycine-containing benzoyldipeptides with aniline was also studied; of these, some gave coupling reactions and some gave transamidation reactions under the conditions investigated.

1. Coupling

Benzoyl- α -aminoacylglycine + aniline \rightarrow

Benzoyl- α -aminoacylglycinanilide

2. Transamidation

Benzoylglycylamino acid + aniline \rightarrow

Benzoylglycinanilide (+ amino acid)

The type of reaction which occurred, transamidation or coupling, depended upon the directive influence of the glycine residue, i.e., its relative position in the peptide chain. The transamidation reactions were shown to proceed via the carboxyl transfer mechanism.

Studies with the racemic diastereomeric pairs of non-glycine containing benzoyldipeptides revealed that in the enzyme-induced coupling with aniline, only the L-L isomer of the D-D, L-L pair showed reactivity to give the anilide as product. The D-L, L-D racemate showed no reactivity under the conditions studied. As a result of the foregoing observations, a new and simplified method was proposed for the identification of diastereomeric dipeptides. This method involved enzyme syntheses in conjunction with microbiological assay of the acid hydrolyzate of the product from the enzymic syntheses.

Enzyme specificity studies were effected with several benzoyl derivatives in the ficin-, chymotrypsin-, and papain-catalyzed anilide syntheses. The results were discussed in the light of contemporary beliefs of enzyme specificity in protease-catalyzed syntheses.

The newly obtained anilides have been characterized.

INTEGRAL EQUATION SOLUTIONS OF ELASTIC PLATE PROBLEMS¹

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The analysis presented in this paper makes use of the theory of linear integral equations to solve elastic plate problems. These problems require the finding of a deflection function $w(x,y)$ which repre-

sents the deflection of the middle surface of the plate from its unloaded position. This deflection function is required to satisfy the Lagrange plate equation,

$$\nabla^4 w(x,y) = q(x,y)$$

throughout the region defined by the plate, where ∇^4 is the two dimensional Laplacian differential operator, D is the flexural rigidity of the plate and $q(x,y)$ is the transverse load distribution on the plate. In addition to satisfying Lagrange's plate equation the deflection function must also satisfy prescribed boundary conditions

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along the periphery of the plate.

The deflection function for a rectangular plate valid in $-a \leq x \leq a$; $0 \leq y \leq b$ with three edges $x = \pm a$, $y = b$ pinned and the edge $y = 0$ clamped is obtained by adding to the known deflection function of a simply supported rectangular plate ($-a \leq x \leq a$; $-b \leq y \leq b$) with $q(x,y) = q(x,-y)$ the deflection which results from superposing an unknown line load along $y = 0$ upon this simply supported plate. The intensity of the unknown line load is determined by the use of an integral equation so that the deflection along the x axis vanishes identically. The slope in the y direction along the x axis will vanish because of the symmetry of the loading and therefore the deflection function for either half of the original simply supported plate ($-a \leq x \leq a$; $0 \leq y \leq b$ or $-a \leq x \leq a$; $-b \leq y \leq 0$) will be a solution for the proposed boundary value problem.

The solution of the integral equation is effected by employing the finite double sine transforms for the deflection $w(x,y)$ and the transverse loading $q(x,y)$ to find the proper sine transform of the required line load. It is assumed that $q(x,y)$ is such that its sine transform exists. A solution of this particular plate problem is obtainable by other methods in terms of a double Fourier series but it cannot be made to coincide in form with the present solution since the latter is represented over a domain twice the size of the domain of the required plate.

The deflection function for a rectangular plate valid in $0 \leq x \leq a$; $0 \leq y \leq b$ with two adjacent edges $x = 0$, $y = 0$ clamped and the other two edges $x = a$, $y = b$ pinned is determined by adding the deflection function for a pinned rectangular plate $-a \leq x \leq a$; $-b \leq y \leq b$ with $q(x,y) = q(x,-y) = q(-x,-y)$ to the deflection which results from superposing two unknown line loads along the x and y axes of the pinned plate. The requirement that the deflection vanish identically along the x and y axes leads to a pair of simultaneous linear integral equations for the unknown line load intensities. It is assumed that the sine transforms for the line loads exist and they are obtained from a doubly infinite system of linear equations. The deflection function for any quadrant of the pinned plate will be a solution for the boundary value problem of a rectangular plate with two adjacent edges pinned and the other two edges clamped.

The solutions obtained for both of these problems are represented in terms of double Fourier series.

The deflection function for an axially symmetric loaded clamped sector shaped plate of central angle $\theta = \pi/2^m$ where m is an integer is obtained in terms of a series of Legendre polynomials. This function is found by adding to the deflection function of an axially symmetric loaded clamped circular plate the deflection function which results from superposing $(m - 1)$ line loads of unknown intensity onto the clamped circular plate. These line loads are along diametral lines equally spaced at an angle of $\theta = \pi/2^m$. The requirement that the deflection vanishes identically along the load lines leads to a simultaneous system of $(m - 1)$ linear integral equations for the determination of the intensity distribution functions of the line loads. The deflection function for any sector of central angle $\theta = \pi/2^m$ of the complete circular plate will be a solution for a clamped sector shaped plate of central angle $\theta = \pi/2^m$. The solutions for a clamped semicircular plate and for a clamped quadrantal plate are given explicitly.

A Fourier-Bessel representation for the deflection function of a finite circular plate of radius a resting on an elastic subgrade and satisfying Navier's boundary conditions $w(a) = 0$, $\nabla^2 w(a) = 0$ is obtained by making use of finite Hankel transforms. It is assumed that the plate maintains continuous contact with the subgrade and that the kernel or "influence function" $k(r,\theta; \rho,\phi)$ which gives the deflection at any point (r,θ) of the surface of the subgrade when a unit load is applied at the point (ρ,ϕ) is known or can be obtained experimentally. An integro-differential equation is developed the solution of which represents the deflection of the plate. By the use of finite Hankel transforms this integro-differential equation is reduced to an algebraic equation in the Hankel transform of the deflection function. The solution obtained is general in that it holds for any axially symmetric load which is representable in a Fourier-Bessel series and likewise for subgrades of differing physical structure. A Fourier-Bessel representation for the reaction pressure of the subgrade on the plate is obtained and it is shown that the reaction pressure is a function of the load distribution, physical characteristics of the subgrade and the size of the plate.

COMPARISONS OF SOME ORGANIC COMPOUNDS CONTAINING GROUP IV-B ELEMENTS¹

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Important types of organic compounds containing Group IV-B elements (silicon, germanium, tin, and lead) were summarized in the literature review from the point of view of comparing the similarities and differences of their chemical properties. Some new organic compounds of silicon and tin were prepared in order to study their properties and to correlate them with those of analogous compounds of other elements in this subgroup.

Hexaphenyldisilane was cleaved by sodium-potassium alloy to give triphenylsilylpotassium. Pentaphenylchlorodisilane was made by the reaction of triphenylsilylpotassium with diphenyldichlorosilane in 50 per cent yield from the recrystallization in petroleum ether (b.p. 60–70°) and melted at 154–155°. 1,1,1,2-Tetraphenyl-2,2-dichlorodisilane was made by the reaction of triphenylsilylpotassium with phenyltrichlorosilane in 34 per cent yield and melted at 98–101°. 1,1,1-Triphenyl-2,2,2-trichlorodisilane was made by the reaction of triphenylsilylpotassium with silicon tetrachloride in 27 per cent yield and melted at 143–145°. Octaphenyltrisilane was made by treating two moles of triphenylsilylpotassium with one mole of diphenyldichlorosilane and recrystallized from a mixed solvent of benzene and ethanol (29 per cent yield); it melted at 260–262°. In another preparation a product of the same composition with a melting point of 302–303° was isolated. Decaphenyltetrasilane was prepared by the coupling reaction of pentaphenylchlorodisilane with sodium in hot xylene in 44 per cent yield; it melted at 359–362°.

A complete series of ten hexaaryldisilanes containing phenyl and *p*-tolyl groups has been prepared. The symmetrical disilanes were made by coupling the triarylchlorosilane with sodium in refluxing xylene. The unsymmetrical disilanes

were prepared either by the treatment of a triarylsilylpotassium with a triarylchlorosilane or by the reaction of a partially arylated hexachlorodisilane with a proper aryllithium compound. The former reaction gave better yields and purer products. Besides hexaphenyldisilane and hexa-*p*-tolylidisilane, other eight new compounds are listed below:

Pentaphenyl-*p*-tolylidisilane (28 per cent yield) was recrystallized from benzene and melted at 283–285°; 1,1,2,2-tetraphenyl-1,2-di-*p*-tolylidisilane (62 per cent yield) melted at 252–253° after recrystallization from benzene; 1,1,1,2-tetraphenyl-2,2-di-*p*-tolylidisilane (72 per cent yield) melted at 229–230° after recrystallizing from a mixed solvent of benzene and petroleum ether (b.p. 60–70°); 1,1,1-triphenyl-2,2,2-tri-*p*-tolylidisilane (26 per cent yield) was recrystallized from a mixed solvent of benzene and petroleum ether (b.p. 60–70°) and melted at 262–264°; 1,1,2-triphenyl-1,2,2-tri-*p*-tolylidisilane (52 per cent yield) melted at 226–227° after recrystallization from a mixed solvent of benzene and ethanol; 1,2-diphenyl-1,1,2,2-tetra-*p*-tolylidisilane (71 per cent yield) melted at 240–241° after recrystallization from benzene-petroleum ether (b.p. 60–70°); 1,1-diphenyl-1, 2,2,2-tetra-*p*-tolylidisilane (57 per cent yield), after recrystallization from benzene-petroleum ether (b.p. 60–70°), also melted at 240–241° (the mixed melting point of this compound and the 1,2-diphenyl-1,1,2,2-tetra-*p*-tolylidisilane also melted at 240–241°); phenylpenta-*p*-tolylidisilane (19 per cent yield) melted at 288–290° after recrystallization from benzene.

Triphenylsilylpotassium adds to *trans*-stilbene to form β -triphenylsilyl- α , β -diphenylethylpotassium which was hydrolyzed to give triphenyl- α , β -diphenylethylsilane (melting point 135–136°) in 39 per cent yield after recrystallization from a mixed solvent of ethanol and petroleum ether (b.p. 60–70°).

The silicon-silicon bond of hexaphenyl-disilane was cleaved by sodium-potassium alloy in ether, potassium in di-*n*-butyl ether, sodium in liquid ammonia, and bromine in carbon tetrachloride, but it was

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not cleaved by sodium dispersion in xylene or in dioxane, sodium amalgam, lithium aluminum hydride, or hydrogen peroxide. 1,1,2,2-Tetraphenyl-1,2-di-*p*-tolyl-disilane and 1,1,2-triphenyl-1,2,2-tri-*p*-tolyl-disilane were not cleaved by iodine or oxygen. Triphenylchlorosilane did not react with lithium in ethylamine to form the solvated free radical, triphenylsilyl ethylamine (1). Instead, the *N*-ethylamino compound was formed in the presence and in the absence of lithium.

Triphenyl-*p*-bromophenyltin could not be obtained by the reaction of triphenyltin chloride with *p*-bromophenyllithium but it could be made from the *p*-bromophenylmagnesium iodide in 72 per cent yield. Triphenyl-*p*-bromophenyltin melted at 133-135° instead of at 224° as reported in the literature (2).

Some methiodides and methosulfates of organotin compounds containing substituted amino groups have been made for the studies of the introduction of water-solubilizing groups. Triphenyl-*p*-dimethylaminophenyltin methiodide (95 per cent yield) was recrystallized from methanol and melted at 167-169° with evolution of gases when heated at the rate of 4 degrees per minute; triphenyl-*p*-dimethylaminophenyltin methosulfate (86 per cent yield)

was recrystallized from methanol and melted 240-243° when heated at the rate of 3 degrees per minute; diphenyldi-(*p*-dimethylaminophenyl)-tin dimethiodide (98 per cent yield) was recrystallized from methanol and melted at 164-168° when heated at the rate of 4 degrees per minute; tetrakis-(*p*-dimethylaminophenyl)-tin tetramethiodide (93 per cent yield) was recrystallized from water and melted with decomposition at 190°; triphenyl- γ -diethylaminopropyltin methiodide (68 per cent yield) was recrystallized from ethanol-petroleum ether (b.p. 60-70°) and melted at 173-175°. The methosulfates of diphenyldi-(*p*-dimethylaminophenyl)-tin, tetrakis-(*p*-dimethylaminophenyl)-tin, and triphenyl- γ -diethylaminopropyltin are very soluble in water but attempts to purify these compounds were unsuccessful.

Triphenylsilyltriphenyltin was made by coupling triphenylsilylpotassium with triphenyltin chloride. Attempts to synthesize triphenylsilyltriphenyllead and triphenylstannyll-triphenyllead by the coupling reaction were unsuccessful.

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CONDUCTANCES, TRANSFERENCE NUMBERS AND ACTIVITY COEFFICIENTS OF SOME RARE EARTH HALIDES¹

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The conductances, transference numbers and activity coefficients of aqueous solutions at 25.0°C. of lanthanum, praseodymium, neodymium, gadolinium and erbium bromides and of gadolinium chloride were determined for concentrations up to 0.1 normal. The accuracy for all determinations was within 0.1 per cent.

The Onsager limiting law for conductance is obeyed for all of the salts studied up to a concentration of about 0.001 normal. The equivalent conductances of the first three bromides mentioned are identical within experimental error. As the atomic number increases beyond neodymium, there is a regular decrease of the conductances of the rare earth bromides. This same general behavior has been previously reported for rare earth chlorides (1). The identical conductances for lanthanum, praseodymium and neodymium bromides may be explained by assuming that a second coordination number for oxygen is available for these rare earth ions as the atomic radius increases with decreasing atomic number. Thus an equilibrium between the two types of hydrated ions would be established which would materially affect their mean ionic radii and should greatly influence their conductances. The decrease in the conductances of the rare earth bromides beyond neodymium is assumed to be due to the hydration of the ions as in the case of the alkali metal ions.

The transference numbers of the rare earth halides were determined by the moving boundary method, and were found to be linear functions of the square root of the concentration as is predicted by the Onsager limiting law for transference numbers. However, the magnitudes of the experimental slopes differed from theory by a factor of approximately one-fifth. This discrepancy between theory and experiment has been previously observed (2) but not explained.

The transference numbers of lanthanum,

praseodymium and neodymium bromides were quite close to each other; this similarity was anticipated in view of the similarity of the conductances of these salts. Also, the transference numbers of the heavier rare earth bromides decreased with increasing atomic number in the same manner as did their conductances.

Concentration cells with transference were employed to determine the activity coefficients of all six halides. The coefficients agreed with those predicted by the Debye-Hückel limiting law when the experimentally determined \bar{a} values were used to calculate the theoretical coefficients.

The distances of closest approach, \bar{a} , for all rare earth halides studied, were found to be larger than the sum of the crystal radii of the cation and of the anion by approximately the diameter of one water molecule. However, the difference between the \bar{a} values of the chloride (3) and of the bromide of the same rare earth was not, in general, equal to the difference in ionic radii of the two anions; the method used for the calculation of these values was not sufficiently sensitive to determine whether the variations of these values are real. Moreover, the values of \bar{a} would be influenced by those assumptions of the Debye-Hückel theory which may not be valid for these poly-valent electrolytes.

Before more definite conclusions may be made concerning the behavior of solutions of rare earth halides, data on the rare earth elements not yet investigated should be obtained. It is hoped that data on the complete rare earth series will permit the further development of satisfactory theories to explain the behavior of poly-valent electrolytes in concentrated solutions.

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THIOCYANATE, THIOUREA AND DITHIOOXAMIDE COMPLEXES OF RUTHENIUM¹

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Ruthenium is one of the large group of elements present in the fission products. It is represented by several activities, among them Ru^{106} which has a 1.0 year half-life and, by reason of its 30 second daughter activity, has a fairly high energy of radiation. The specific interest in its active isotopes, together with the general lack of knowledge about its chemistry, has given strong impetus to the study of all aspects of the chemistry of ruthenium.

Since very few investigations have been carried out on the fundamental nature of ruthenium complexes stable only in solution, it was the purpose of this work to study, by means of spectrophotometry, three such complexes. The investigation had as its immediate objective the determination of the formulae and the stability constants of the thiocyanate, thiourea and dithiooxamide complexes of ruthenium.

In this spectrophotometric investigation it was found that the ruthenium IV was being reduced to ruthenium III at the expense of the complexing agent. Consequently the absorption spectrum of the uncomplexed ruthenium was unknown, and the usual methods of interpretation of spectrophotometric data were not applicable. A new method of interpretation of spectrophotometric data was developed for systems containing either one or two complexes. This method is applicable for systems in which the complexes have small formation constants, providing the absorption spectrum of the last complex can be determined experimentally. Equations were developed for calculation of the formulae, extinction coefficients, and stability constants of the complexes present.

It was found that both ruthenium III and ruthenium IV perchlorate react with thiocyanate to form a deep-blue complex, with a formula $\text{Ru}(\text{CNS})_3^{+2}$. The absorption spectrum of $\text{Ru}(\text{CNS})_3^{+2}$ was determined experimentally. At an ionic strength

of 1.0, the complex, which is essentially independent of the concentration of acid present, has a formation constant of 60 ± 1 . No evidence was found for higher complexes.

The investigation revealed that both ruthenium III and ruthenium IV perchlor-

ate react with thiourea, $\text{H}_2\text{N}-\overset{\text{S}}{\underset{\text{||}}{\text{C}}}-\text{NH}_2$, to give two blue-green complexes, $\text{Ru}(\text{th})_3^{+2}$ and $\text{Ru}(\text{th})_2$. The complexing agent behaves as an acid, each molecule of thiourea releasing a proton. At an ionic strength of 3.0, the monothiourea complex was found to have a formation constant, K_1 , equal to 16.3 ± 0.5 , while the constant, K_2 , of the trithiourea complex was found to be equal to 5.30 ± 0.11 . The absorption spectrum of $\text{Ru}(\text{th})_3$ was determined experimentally, and that of $\text{Ru}(\text{th})_2^{+2}$ was determined by calculation. The magnetic susceptibility per gram of $\text{Ru}(\text{th})_3$ was found to be 3.0 ± 1.5 cgsu/g at 20°C . This determination, indicated, within the limit of experimental error, that the ruthenium in the complex was present as ruthenium III. No evidence was found for the existence of the complex $\text{Ru}(\text{th})_2^{+4}$.

It was found that both ruthenium III and ruthenium IV perchlorate react with di-

thiooxamide $\text{H}_2\text{N}-\overset{\text{S}}{\underset{\text{||}}{\text{C}}}-\overset{\text{S}}{\underset{\text{||}}{\text{C}}}-\text{NH}_2$, in acetic acid to give two blue-green complexes, $\text{Ru}(\text{dt})_3^{+2}$ and $\text{Ru}(\text{dt})_2$. The complexing agent behaves as an acid, each molecule of dithiooxamide releasing a proton. The reactions themselves are independent of the concentration of acetic acid present, although changing the acetic acid concentration alters the solvation of the ruthenium. At an ionic strength of 1.0, the monodithiooxamide complex was found to have a formation constant, K_1 , equal to $[9.3 \pm 0.3] \times 10^3$, while the tridithiooxamide complex was found to have a formation constant, K_2 , equal to $[8.3 \pm 0.2] \times 10^3$. The absorption spectrum of $\text{Ru}(\text{dt})_2$ was determined experimentally, and that of $\text{Ru}(\text{dt})_3^{+2}$ was determined by calculation. No evidence was found for the existence of a complex $\text{Ru}(\text{dt})_2^{+4}$.

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VARIATION OF NON-PROTEIN-NITROGEN VALUES IN HEAT-TREATED MUSCLE TISSUES¹

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Canned meat items, especially beef, have certain palatability defects. Those which are considered to be the most serious are the so-called "canned" meat flavor and the "mushy" texture, the latter being the more objectional. The investigations on canned beef have been directed to studies on the bactericidal effects of heat processing. Consequently, little fundamental knowledge is available concerning chemical changes which may occur.

This problem was undertaken on the hypothesis that proteolytic changes due to an increased proteolytic activity during the initial stages of thermal processing, in addition to chemical hydrolysis of the meat proteins during processing, may be in part responsible for the "mushy" texture.

Autolysis studies (using chicken breast and beef muscle) were conducted to characterize the proteolysis which is observed to occur during the aging of meat, and to clarify similar chemical reactions which may occur in heat processing and canning. The data showed that tenderization of meat during storage is the result of changes other than the enzymic decomposition (proteolysis) of muscle proteins. This physical alteration could be the result of minute chemical changes in the proteins due to autolysis. However, the conclusion was reached that proteolysis, accelerated during processing, may be in part responsible for the "mushy" texture of canned beef.

Thermal processing experiments were conducted to study the chemical changes which may occur in beef proteins during thermal processing and their effects on

the texture of the meat. In addition, the relationship between these chemical changes and certain processing variables was studied.

The method used to determine these changes involved a fractionation of nitrogen into that which is soluble in trichloroacetic acid and in tungstic. The processing variables studied were the size of the piece of meat canned, processing temperature, and processing time. Time and temperature were treated as independent variables, although it was recognized that in processing they are, more or less, dependent on each other.

The processing results presented evidence for the following conclusions:

1. Proteolytic changes in beef, similar to those observed in aging meat, which may occur during the initial stages of heat processing, appear to be responsible in part for the "mushy" texture of canned beef. Although not directly responsible for this texture defect, they may bring about a physical alteration in the meat proteins by a change in chemical constitution. This physical alteration may be in part responsible for the "mushy" texture.

2. The texture defect cannot be explained *in toto* by the conversion of collagen to gelatin, since the extent of the change in the trichloroacetic-acid-soluble-nitrogen as a result of processing cannot be entirely explained by this conversion. This change (an increase) was interpreted to indicate the degradation of other muscle proteins.

3. The changes which occurred during processing in the nitrogen fractions are related only to length of processing time. No definite relationship with processing temperature could be established. The relationship with the size of the piece of the meat could not be evaluated.

1 a. Chairman of Committee, R. R. Sealock, Dept. of Food Technology (Chemistry).
b. Doctoral Thesis No. 1245. Submitted January 25, 1952.
2 a. B.S., University of Rhode Island, 1940.
M.S., *ibid.*, 1942.

MASTERS' THESES

Accepted July 1, 1951 — June 30, 1952*

SUMMARY AND INDEX

The following summaries and indices may prove helpful to those interested in tabulations and to those who may wish to examine theses in the same or related fields.

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 2. Masters' theses accepted July 1, 1951 — June 30, 1952 — 223.
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Agricultural Engineering—Total 8. Bhagwati, Bond, Calderwood, Chaudhary, Fuhrwerk, Glover, Yoerger, Zahradnik.
Agronomy—Total 8. Andharia, Bennett, Hoover, Matzinger, Mehta, Raeber, Smit, Thuma.
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Dairy Industry—Total 1. McDowell.
Economics and Sociology—Total 17. Ando, Downey, Easley, Goffin, Godsell, Hoffmann, Hulse, Huston, Judy, McGovern, Muirhead, Peterson, G. A., Robbins, Thomas, Tokoro, Toussaint, Wunderlich.
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* A list of Masters' theses accepted September 1, 1950 — June 30, 1951 is included in No. 2, Vol. 26 of the Iowa State College Journal of Science.

AUTHORS AND TITLES

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- Adams, Alonzo Theodore. Effect of subtilin and heat in preventing spoilage of comminuted beef. Food Bacteriology.
- Allen, Leo Patrick. Growth and nutrition of *Micrococcus lysodeikticus*. Physiological Bacteriology.
- Allen, Robert Max. Factors affecting the rooting of cottonwood cuttings. Forest Management.
- Ames, William B. Survey methods used in estimating retail expenditures of a college newspaper's subscribers. Technical Journalism.
- Anderegg, John Alden. Oxidation of chloride ion by cerium (IV). Physical Chemistry.
- Anderson, Willard Raymond. Implications for adult education in agriculture from responses of participants in the veterans farm training program in the central region: I. Administration. Agricultural Education.
- Anderson, William Arthur. A proposed community school for Villisca, Iowa. Vocational Education.
- Andharia, Rantilal Mohanlal. Soil nitrogen status of marshall silt loam as influenced by crop rotations. Soil Management.
- Ando, Kyo. Japanese agricultural price policy. Agricultural Economics.
- Armstrong, Philip Edward. The zirconium-germanium alloy system. Chemical Engineering.
- Aurand, Elmer Carol. Forecasting probability of college graduation of Ames High School graduates. Industrial Education.
- Babcock, Joyce Virginia. Life insurance information and practices of homemakers in Ames, Iowa. Home Management.
- Bagatell, Fillmore Kenneth. Utilization of pyrimidine bases by *Aerobacter aerogenes*. Bacteriology.
- Baker, Dale Alton. Fault-actuated bustie switches for improving transient stability. Electrical Engineering.
- Baker, Robert Swain. Factors in biosynthesis of and stimulation by aromatic amino acids in *Lactobacillus arabinosus*. Biochemistry.
- Bancroft, John Franklin. Differential characteristics of pupils electing ninth grade industrial arts in Davenport. Industrial Education.
- Barnes, Richard Allen, Jr. Prediction of general science achievement in five Story County high schools. Vocational Education.
- Barson, Norman. Performance characteristics of a centrifugal extractor. Chemical Engineering.
- Bealer, Laurene Nelson. Personal value patterns of pupils in two high schools in New Mexico. Home Economics Education.
- Bell, Max Ewart. Development of the embryo of *Zea* in relation to position on the ear. Plant Morphology.
- Bennett, William Frederick. Nitrogen, phosphorus, and potassium content of the corn leaf and grain as related to nitrogen fertilization and yield. Soil Fertility.
- Bennison, Robert William. Effects of antibiotics and vitamin B₁₂ on pantothenic acid requirements of growing-fattening swine. Animal Nutrition.
- Berg, Raymond Arthur. A rectangular fluorescent source. Electrical Engineering.
- Betts, Merle Edward. Probability of mortality in first quarter chemistry for students of agriculture at Iowa State College. Agricultural Education.
- Bhagwati, Lalit Kumar N. Laboratory measurements of air permeability of hay. Agricultural Engineering.
- Bjorck, Lillian Lucy. Urinary excretion of thiamine, riboflavin and pantothenic acid by lactating stock rats. Nutrition.
- Blumeyer, Elra John. A proposed community school for Goldfield, Iowa. Vocational Education.
- Bobkoff, Kenneth Bruce. Stress-strain investigation of a prestressed beam of concrete blocks. Structural Engineering.
- Bond, Theodore Eugene. Development of a plate-type heat exchanger for use in animal shelter ventilation. Agricultural Engineering.
- Browning, James Cole. The *Phalaenidae* (Noctuidae) of Central Iowa. Entomology.
- Butler, John Parkman. The separation of silver from copper by electrodeposition from ammoniacal solution. Analytical Chemistry.
- Buxton, Frank Edwin. Food habits of the white-tailed deer. *Odocoileus virginianus* Boddaert, in Boone County, Iowa. Wildlife Management.
- Calderwood, David Lloyd. Attractiveness of lighted surfaces to European corn borer moths and other insects. Agricultural Engineering.

- Campbell, Louis Lorne. Electrostatic field in a metal. Physics.
- Castro, Jose de Jesus. Ecological studies on the anguomolis grain moth, *Sitotroga cerealella* Oliv., and the rice weevil, *Sitophilus oryza* L. Entomology.
- Chaudhary, Iqbal Ahmad. Effect of grain moisture on efficiency of harvesting machinery for oats and corn. Agricultural Engineering.
- Coburn, Jessie Ardelle. Adaptation of an inventory to determine values used by twelfth-grade girls in selecting food. Home Economics Education.
- Collier, John Raymond. A survey of beta-hemolytic streptococci from swine. Veterinary Bacteriology.
- Cook, Charles Clyde. Quantitative spectrographic determination of common impurities in calcium and its compounds. Physical Chemistry.
- Costa, Robert Richard. Food habits of the raccoon, *Procyon lotor hirtus* N. and G., in Central Iowa. Wildlife Management.
- Cox, Robert Payne. Solvent recovery in a liquid-liquid extraction system. Chemical Engineering.
- Cox, Streatfield Hooper, Jr. Physical characterization of some Iowa soils. Soil Physics.
- Cuff, Barbara Jane. Form of response and subtest validity in a mathematics aptitude test. Applied Psychology.
- Cuff, Peter William Whitby. Effect of vitamin B₁₂, APF, and antibiotics on enteritis in Swine. Animal Nutrition.
- Curde, Ted W. Predicting achievement in the trade and industrial orientation course at Des Moines Technical High School. Vocational Education.
- Daly, Mary Viola. Attempts to influence egg production of *Hymenolepis diminuta* with sulfaquandine and sodium salicylate. Zoology.
- Davidson, Stanley. Project completion as related to the financing of 4-H Club agricultural projects. Vocational Education.
- Davis, Norman T. Morphology of the female organs of reproduction in the Meridae (Hemiptera). Entomology.
- Davison, Della Buell. Vocabulary test on textile finishes for college students. Textiles and Clothing.
- DeBoodt, Marcel Florent. Physical characterization of some Iowa soils. Soil Physics.
- Decker, Richard Warren. Photoelectric work function of the borides of lanthanum, praseodymium and neodymium. Physics.
- DeFore, Robert Charles. Relationship of interscholastic athletic participation to scholastic achievement and personal-social adjustment among junior high school boys. Vocational Education.
- Denton, Ralph Robert. Germination and establishment of the common barberry. (*Berberis vulgaris* L.) Plant Ecology.
- Ditsworth, Richard Lee. Through-circulation drying of cut corn. Mechanical Engineering.
- Donovan, George Robert. Relationship between size of school, professional preparation, experience and salaries of teachers in Iowa towns with less than 2,500 population. Vocational Education.
- Downey, Carroll Edward. Economic analysis of international buffer stock proposals. Agricultural Economics.
- Doyle, Barrett. A critical examination of thermistor lag-time. Physics.
- Dreis, Robert Edward. Productivity of the wood duck, *Aiz sponsa* (L.), in Eastern Louisa County, Iowa, 1951. Wildlife Management.
- Duffield, Paul Calvin. Simultaneous use of fungicides and insecticides as seed treatments. Plant Pathology.
- Easley, Eddie Vee. Economic effects of milk sanitation regulations on supply and demand in Omaha-Council Bluffs marketing area. Agricultural Economics.
- Ebel, Marvin Emerson. Orbital electron ejection in large-angle scattering. Theoretical Physics.
- Eiser, Arthur Louis, Jr. Competition between corn and weeds. Plant Ecology.
- Elliott, Dean Alexander. Implications for adult education in agriculture from responses of participants in the veterans farm training program in the Central Region: II, Course Content. Agricultural Education.
- Fields, John Forrest. Practices related to the individual inventory in Iowa high schools. Vocational Education.
- Finkner, Ralph Eugene. Differential reaction of oat varieties to powdery mildew, *Erysiphe graminis* DC. Crop Breeding-Plant Pathology.
- Fisher, John Edwin. Floral induction in soybeans. Plant Physiology.
- Fitzwater, Donald Robert. Structure of neodymium sulfate octahydrate. Physical Chemistry.
- Fossum, Guilford O. Deoxygenating effects of artificially raising the temperature of a stream. Sanitary Engineering.
- Frey, Richard Emil. Reaction time under conditions of preoccupation with and without a warning signal. Industrial Education.
- Fuhrwerk, Victor C. Application of infrared lamps to the drying of agricultural grains. Agricultural Engineering.
- Gaertner, Ruth Henderson. Student employment in food services of coeducational colleges and universities with enrollments of 1,000 to 7,000. Institution Management.
- Garcia, Pilar A. Relation of age and serum cholesterol to rate of fat absorption in adult women. Nutrition.
- Geiser, Doyle Stanley. Opinions of Iowa seed dealers concerning certified seed. Technical Journalism.
- Getty, Russell Elias. Forest composition, volume, and growth in Johnson County, Iowa. Forestry.

- Ginter, Eileen Loraine. Identification and colorimetric determination of the oxidases of corn root tips. *Plant Physiology*.
- Glover, William Raymond. An engineering valuation of the principle of self-propelled transport for farm machines. *Agricultural Engineering*.
- Gnecco, Jose Manuel. Effects of overheating on some chemical and physical properties of an asphalt cement. *Highway Engineering*.
- Godsell, Thomas Ernest. Labour and machinery substitution on Iowa cash-grain farms. *Agricultural Economics*.
- Goffin, Paul Constant. Economic analysis of cream assembly costs. *Agricultural Economics*.
- Goforth, Joyce Parker. Assertive behavior of preschool children as related to their preferences for assertive behavior in playmates. *Child Development*.
- Goodman, Jarrett W. Effectiveness of solid geometry as a prerequisite for engineering drawing. *Vocational Education*.
- Grigg, Leslie Raymond. Forecasting high school graduation at the ninth grade level in the McKinley High School at Cedar Rapids. *Industrial Education*.
- Grondahl, Carroll Robert. Winter movements of the ring-necked pheasant, *Phasianus colchicus torquatus* (Gmelin), in Winnebago County, Iowa. *Wildlife Management*.
- Groom, Jane Louise. Problems in personal-social relationships recognized by girls in two public junior high schools. *Home Economics Education*.
- Gucum, Irfan. An apparatus for the determination of thermal conductances of solid materials. *Mechanical Engineering*.
- Hamilton, James Dixon. Implications for adult education in agriculture from responses of participants in the veterans farm training program in the Central Region: III. Methods of instruction. *Agricultural Education*.
- Hamlin, Jack DeVern. Effectiveness of two-hour and three-hour laboratory periods in the teaching of descriptive geometry. *Vocational Education*.
- Hansen, Robert James. Sampling procedures for roadside interviews in origin and destination traffic surveys. *Highway Engineering*.
- Hartel, Arline S. Demonstrations to build the homemaker's confidence in selection of color, furnishings and accessories for her home. *Applied Art*.
- Hermann, Paul Jacob. Propagation of stress waves in a two-dimensional elastic medium. *Theoretical and Applied Mechanics*.
- Hoffmann, Randall Arnold, Jr. Economic analysis of Iowa dairying. *Agricultural Economics*.
- Holmes, Noah Dortch. Communications media through which Iowa farm operators obtain agricultural out-look information. *Technical Journalism*.
- Holt, Imy Vincent. Initiation and development of the inflorescence in *Phalaris arundinacea* L., *Dactylis glomerata* L., and *Andropogon gerardi* Vitman. *Plant Morphology*.
- Honeycutt, Julian Bernard, Jr. Preparation of some nitrogen-containing organosilicon compounds. *Organic Chemistry*.
- Hoover, Max Manley, Jr. Combining ability in sweetclover, *Melilotus officinalis* Lam. *Crop Breeding*.
- Howell, Keith Holman. Effects of primary tillage practices on growth of corn. *Plant Ecology*.
- Hsu, Robert Ying Hwang. Effects of foliar applications of urea on apple trees. *Horticulture-Botany*.
- Hubbard, Fred H. Productivity of the cottontail rabbit, *Sylvilagus floridanus mearnsii* (Allen), in Decatur County, Iowa, 1951. *Wildlife Management*.
- Hulse, Gene Wood. Changes in cost structure on farms with accounting records. *Agricultural Economics*.
- Hurst, Thomas Lighthall. A quantitative method for determining sequences of amino acid residues. *Bio-organic Chemistry*.
- Huston, Dean Merlin. Analysis of the productivity of farm labor in Iowa. *Agricultural Economics*.
- James, William Joseph. X-ray investigation of the cyclohexaamylose-iodine complex. *Physical Chemistry*.
- Jensen, Bonnie Egeland. Parent-child resemblances in eight intellectual functions. *Applied Psychology*.
- Judy, Marvin Thornton. Organization and administration of a Methodist Church District: A Sociological Analysis. *Sociology*.
- Kaffetzakis, John G. Response of ruminating dairy calves to aureomycin feeding. *Dairy Husbandry*.
- Kalahar, Kenneth Edward. Evaluation of aptitude tests for forecasting achievement in high school mechanics. *Vocational Education*.
- Kessler, Kenneth William. Forecasting probability of college matriculation for graduates of small Central Iowa high schools. *Vocational Education*.
- Klippenstein, Donald Leo. Normal families of functions. *Mathematics*.
- Kono, Tokuwu. Monograph of the sericothrips in the United States, with notes on the biology of *Sericothrips variabilis* (Beach). *Entomology*.
- Kopf, Grace Elizabeth. Conditioned inhibition as a function of work-surface height. *Psychology*.
- Larsen, Howard James. Effects on ruminating calves of changing to omasal-omosal feeding through a rumen fistula. *Dairy Husbandry*.
- Laursen, Henry Gerald. Changes in thin organic films caused by electron bombardment. *Physics*.
- Littlefield, Ruth Evelyn. Relation of crying of infants to certain characteristics of students responsible for the infants'

- care in the Home Management Houses. Child Development.
- McCart, Dorothy Jean Dix. Adequacy of line drawings to characterize face designs of people. Textiles and Clothing.
- McCoy, Chauncey Edward. Relationship of the four spotted fungus beetle, (*Glischochilus q. quadrisignatus*) (Say) to European corn borer populations. Entomology.
- McCoy, James Edward. Relationship of freshman speed and comprehension in reading to fourth year engineering matriculation. Applied Psychology.
- McDill, Robert Lewis. Seeding experiments on highway backstops. Plant Ecology.
- McDowell, Ralph Lynn. Selection of lactic Streptococci for dairy cultures. Dairy Bacteriology.
- McGovern, Helen Drake. Some aspects of consumption economics education at Des Moines Technical High School. Consumption Economics.
- McIsaac, Lyle Delbert. A new technique for the separation of radiophosphorus from sulfur. Physical Chemistry.
- Maddock, Helen Marie. Concentration of aureomycin in sows' blood and milk after oral administration of aureomycin hydrochloride. Statistics.
- Madison, Olga Borghild. Planning church kitchens. Institution Management.
- Madison, Ralph Louis. The Maytag double line chart as a statistical aid in controlling quality of production. Statistics.
- Mandas, John Nicholas. Gravimetric determination of cobalt. Analytical Chemistry.
- Manock, James Clifton. Implications for the secondary school curriculum revealed by a survey of draftsmen in industry. Industrial Education.
- Marihart, Earl E. History of adult evening schools at Dubuque, Iowa. Industrial Education.
- Martin, Truman Glen. The effect of method of preservation on the quality of alfalfa silage stored in miniature silos. Dairy Husbandry.
- Mathews, Gwendoline Hyacinth. Food group factors for a short method of dietary study in a state hospital in Iowa. Institution Management.
- Matzinger, Dale Frederick. Comparison of three types of testers for the evaluation of inbred lines of corn. Crop Breeding.
- Mehta, Niranjan Chhotalal. Determination of organic phosphorus in soils. Soil Fertility.
- Meilike, Donald John. Trend of enrollment in supervised swine projects by vocational agriculture pupils and its relationship to farm income. Agricultural Education.
- Miller, Robert Eugene. Carbohydrases of molds with special reference to the content and isolation of limit dextrinase. Bio-physical Chemistry.
- Mills, Helen Hancher. Farm family housing needs and preferences in the north Central Region: III. Implications for educational programs in homemaking. Home Management.
- Montgomery, Andrew Harrison. Vapor pressure equations. Plant Ecology.
- Moore, William Dean. Inheritance of a light blue underfur character in natural ranch mink, *Mustela vison*. Genetics.
- Morris, Edward Paramount, Jr. Scholastic aptitude and grade point average as factors in stated and present occupational choice. Vocational Education.
- Morrison, John Irwin. Polarography of the Vitamin B₁₂. Analytical Chemistry.
- Muirhead, Robert Colin. Competitive position of animal fats in relation to some vegetable oils. Agricultural Economics.
- Murie, Richard Alden. Physical and chemical studies on Vitamin B₁₂. Analytical Chemistry.
- Nady, Robert M. Effect of various methods of asphalt cement introduction on hot asphaltic concrete mixes. Highway Engineering.
- Nelson, Charlotte Genova. Certain factors influencing the choice of professional occupations. Vocational Education.
- Nelson, Courtenay. Effectiveness of sound motion pictures in teaching a unit on sulfur in high school chemistry. Vocational Education.
- Nevitt, Thomas D. Some reactions of negatively substituted furans with powerful nucleophilic reagents. Chemistry.
- Nordquist, Edwin Clyde. Bearing capacity of groups of friction piles. Soil Engineering.
- Nylin, Florence Irene. Emphasis on family life education in selected elementary schools of Wisconsin. Home Economics Education.
- Olson, Raymond Henry. The distribution of orally administered P³² in the young calf. Biochemistry.
- Olate, Burton Torres. Methods for sampling soil from replicated field experiments. Statistics.
- Olate, Luz Uichanco. Beef cooked in water: Effect of temperature of cooking upon palatability. Foods.
- Ortmeyer, Muriel Winona. Reactions of a group of children and their parents to facial expressions of emotion in pictures. Child Development.
- Ottis, Kenneth. Blood platelet counts of the albino rat, golden hamster and rabbit. Physiology.
- Overby, James Fred. Professional preparation of rural school administrators in Iowa. Vocational Education.
- Parchen, Frank Raymond. Kinetics of the reduction of ferric iron by hydroquinone in the presence of 1,10-phenanthroline. Physical Chemistry.
- Patel, Bhailal Shivabhai. Nature of distillation lines in ternary azeotropic systems. Chemical Engineering.
- Patel, Dahyabhai Jerambhai. Effect of moisture on the extraction rate in solvent extraction of cottonseed and soybeans. Chemical Engineering.

- Pechenuik, Olga. Selected economic indicators as measures of economic status of farm families in the North Central Region. Home Management.
- Peiffer, Leo Clement. A design for a rural consolidated school in Linn County, Iowa. Architectural Engineering.
- Perdue, Charles Emery. Implications for adult education in agriculture from responses of participants in the veterans farm training program in the Central Region: VI. Course content of present program. Agricultural Education.
- Petersen, Ella Buddenhagen. Evaluating emphasis in the use of audio-visual aids for teaching sixth grade arithmetic. Vocational Education.
- Peterson, Esther Kimmel. An instrument to test the ability of ninth grade girls to apply generalizations relating to child development. Home Economics Education.
- Peterson, Glenn Walter. Relative toxicity of legume seed protectants to two species of *Rhizobium*. Plant Pathology.
- Peterson, Gustaf Adolph. Firm-household interrelationships in agriculture. Agricultural Economics.
- Poole, Dewey Donald. Black stem of oats caused by *Leptosphaeria avenae*. Plant Pathology.
- Poole, Nada Dorris. Use of different combinations of laundry appliances. I. Dryer and conventional washer for weekly family laundry. Household Equipment.
- Poteet, Robert Eugene. Distribution of strains in a rigid frame with members of high stiffness ratio. Structural Engineering.
- Poulter, James Radley. An evaluation of the effectiveness of the Iowa County School administration law. Rural Education.
- Probst, Robert Theobald. Metazoan parasites of the northern black bullhead, *Ameiurus melas melas* (Rafinesque), in Iowa lakes. Parasitology.
- Puttmann, Wayne Carroll. Services offered in small communities in Western Iowa whose high schools were closed between 1939 and 1949. Vocational Education.
- Raeber, Joseph Gottlieb. Effectiveness of selection for yield in soybean crosses by bulk and pedigree systems of breeding. Crop Breeding.
- Raether, Louis Otto. Enolization of some cyclic diketones. Physical-Organic Chemistry.
- Raines, Dolla Glenn. Preparation of teachers for farm management instruction in all-day classes in Vocational Agriculture. Agricultural Education.
- Read, Alvin Ashley. A continuously variable 0.5-100 ampere control system for research applications. Electrical Engineering.
- Reinbach, Loyal Marion. Prediction of permanency in teaching for college students qualifying to teach Vocational Agriculture. Agricultural Education.
- Rhodes, Clarence Lloyd. Implications for adult education in agriculture from responses of participants in the veterans farm training program in the Central Region: IV. Needs. Agricultural Education.
- Robbins, Charles Lewis. Awareness of the problem of prejudice against ethnic-racial-religious groups. Sociology.
- Robinson, Rhee Richard. Influence lines for the design of hingeless arches. Structural Engineering.
- Rook, Charles Wesley. Unit-function transient response of low-pass m-derived filters. Electrical Engineering.
- Rossing, Thomas Dean. An oscillator for acoustic interferometry. Physics.
- Russi, Ralph Frederick. Constitution diagram of the antimony-zirconium alloy system. Physical Chemistry.
- Sadanaga, Kiyoshi. Inheritance of the ability to store sucrose in the maize stalk. Genetics.
- Schoening, Robert Franklin. Laboratory study of the relationship between moments and deflections of corrugated metal culvert pipes. Structural Engineering.
- Schroeder, Lavern Henry. Suggestions for revision of the Lone Rock, Iowa, high school curriculum. Vocational Education.
- Schuler, Josef Franz. Gene frequency of seed and seedling characters in corn. Plant Breeding.
- Seaver, Lloyd H. Some possibilities of economies in the purchasing of school supplies by Iowa school districts maintaining high schools. Vocational Education.
- Shinn, Lorena Mae. Histological studies of the banded milkweed bug, *Oncopeltus fasciatus* (Dall). Entomology.
- Sidles, Paul Howard. Thermal conductivity of metals at high temperatures. Physics.
- Smit, Anton Gysbertus. Parent-inbred progeny relationships of selected orchardgrass clones. Crop Breeding-Genetics.
- Smith, Owen Edward. Dissociation constants of chloranilic acid. Physical Chemistry.
- Sparling, Shirley Ray. Vascular flora of the Chillicothe and Chula Quadrangles, Missouri. Systematic Botany.
- Specht, Gordon Dean. Development of a cycloidal chute. Chemical Engineering.
- Stalder, Harold Irvin. Speed and pattern distribution as factors in the perception of relative motion under conditions of low illumination. Vocational Education.
- Stilley, George Donald. Aerodynamic damping of galloping conductors. Aeronautical Engineering.
- Stringer, Charles Stephen. Dismutation of pyruvate and phenylpyruvate by *Micrococcus pyogenes*. Physiological Bacteriology.

- Svien, Thomas A. Factors affecting the cold test germination of corn. *Economic Botany*.
- Swartzendruber, Dale. A comparison of methods for evaluating soil structure. *Soil Physics*.
- Taylor, Howard Lewis. Effect of plot shape on experimental error. *Statistics*.
- Tebo, Leonidas Brockman, Jr. Bottom fauna of a shallow eutrophic lake, Lizard Lake, Pocahontas County, Iowa. *Economic Zoology*.
- Teer, James Garth. Controlled waterfowl hunting on a state-owned public shooting ground, Forney Lake, Iowa, 1950. *Wildlife Management*.
- Theophilus, Wadhawa. An evaluation of certain schools in Iowa based upon a check list of criteria for a community school. *Vocational Education*.
- Thomas, John Warren. Factors related to the success and failure of farm operators in acquiring farm ownership in Milford Township, Story County, Iowa, since 1925. *Agricultural Economics*.
- Thomforde, Clifford John. Ground conductivity in the Red River Valley determined by electromagnetic wave attenuation. *Electrical Engineering*.
- Throneberry, Glyn Ogle. Some aspects of the tetrazolium reaction in seeds and the enzymes involved. *Plant Physiology*.
- Thuma, Richard Leroy. Evaluation of S progenies of Alfalfa, *Medicago sativa*, for leafhopper resistance variability and yield. *Crop Breeding*.
- Tokoro, Hideo. Japanese land reform program. *Agricultural Economics*.
- Toussaint, William Douglas. Effects of lease arrangements on farm income and improvements. *Agricultural Economics*.
- Trueblood, Gerald Elwood. Predicting achievement in algebra from the Iowa test of educational development. *Vocational Education*.
- Udoh, Benson Akpan. Industrial education baccalaureate graduates of Iowa State College from 1921 to 1950. *Industrial Education*.
- Underwood, Charles Lynn. Validation of a community school criteria check list. *Vocational Education*.
- Van Fleet, Farmer Dell. A psychological examination accuracy score for use in student counseling. *Applied Psychology*.
- Warren, Marshall Garnett. Implications for adult education in agriculture from responses of participants in the veterans farm training program in the Central Region: VII. Audio-visual materials and methods. *Agricultural Education*.
- West, Dale Wilson. Rapid techniques for purity analysis of chaffy grasses. *Economic Botany*.
- Wilder, David Randolph. Some effects of titania on fireclay refractories. *Ceramic Engineering*.
- Wiley, John Shepard. The effect of process variables on the performance of a continuous horizontal-tube reactor. *Chemical Engineering*.
- Williams, Velma Lorraine. Removal of soil from fabric laundered in home washers. I. Soft and hard water; number of rinses and temperature of rinse water. *Household Equipment*.
- Winey, Calvin McCoy. Flow of water in complex pipe networks. *Sanitary Engineering*.
- Wittler, Waneta Amelia. Development of a method of identifying home management problems of farm families. *Home Management*.
- Wunderlich, Gene Lee. Private costs from public benefit projects: A case study of waterfowl depredations on small grains in North Dakota. *Agricultural Economics*.
- Yoder, Wayne DeGrove. Antigenic typing of *Pasteurella multocida* by using chicken embryo vaccine in mice. *Veterinary Hygiene*.
- Yoerger, Roger Raymond. Liquefied petroleum gas as a farm tractor fuel. *Agricultural Engineering*.
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- Zimmerman, Harold Lee. Bedrock geology of western Story County, Iowa. *Geology*.
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PUBLICATIONS OF MEMBERS OF THE STAFF OF THE IOWA STATE COLLEGE FOR THE ACADEMIC YEAR 1951-52

Certain summaries and indices are of interest in a survey of the publications of members of the staff of an educational and research institution such as the Iowa State College. The publications are listed in alphabetic order under the names of the senior authors. Junior authors are also listed alphabetically with cross reference to senior author.

SUMMARY

Number of individuals listed	606
Number of publications	608
Number of publications with joint authorship	334
Number of publications with single author	274
Number of departments or fields represented in publications	41
Number of research agencies represented in publications	7
Number of individuals who serve as editors or on the editorial staff of one or more scientific or technical periodicals	24

The individuals thus serving are: Arias, Buchanan, Burroughs, Carlander, Caughey, Chamberlin, Clark, Fassell, Gilman, Hooker, Hurley, Knight, Paddock, Parks, Pierre, Ross, Schwartz, Sheperd, Shull, Snedecor, Sprague, Swanson, Tintner, Werkman.

INDEX TO PUBLICATIONS BY DEPARTMENTS OR FIELDS

The numbers which follow the names of the departments refer to the index number of the alphabetic list by authors.

Agricultural Engineering: Total 14—Numbers 31, 32, 105, 106, 206, 207, 208, 209, 337, 382, 383, 416, 417, 493.	Civil Engineering: Total 17—Numbers 84, 85, 115, 198, 199, 200, 273, 274, 353, 354, 411, 412, 522, 523, 524, 544, 565.
Agronomy: Total 56—Numbers 22, 33, 98, 99, 100, 101, 153, 154, 202, 244, 245, 275, 290, 310, 311, 312, 318, 319, 328, 329, 330, 331, 339, 340, 346, 348, 349, 355, 373, 387, 390, 391, 393, 413, 442, 453, 459, 464, 486, 487, 501, 512, 513, 515, 535, 536, 537, 542, 570, 573, 585, 586, 587, 596, 597, 598.	Dairy Industry: Total 15—Numbers 2, 15, 102, 117, 118, 190, 406, 424, 463, 464, 566, 567, 574, 606, 607.
Animal Husbandry: Total 20—Numbers 1, 7, 17, 18, 68, 69, 70, 71, 82, 83, 86, 87, 110, 272, 277, 359, 384, 422, 454, 534.	Economics and Sociology: Total 31—Numbers 23, 42, 240, 241, 242, 278, 279, 280, 281, 282, 283, 284, 285, 286, 287, 305, 306, 307, 308, 385, 386, 420, 421, 460, 494, 495, 555, 556, 557, 558, 601.
Bacteriology: Total 23—Numbers 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 65, 184, 364, 400, 444, 484, 485, 518, 519, 591, 592, 593.	Electrical Engineering: Total 4—Numbers 38, 174, 313, 458.
Botany: Total 31—Numbers 6, 88, 89, 124, 170, 238, 239, 295, 302, 303, 322, 323, 324, 325, 326, 327, 379, 380, 419, 462, 480, 481, 492, 496, 497, 498, 499, 500, 514, 559, 577.	English and Speech: Total 1—Number 381.
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Chemistry: Total 61—Numbers 2, 16, 64, 81, 90, 126, 127, 128, 178, 179, 180, 181, 182, 183, 186, 187, 188, 189, 193, 194, 195, 215, 216, 217, 218, 219, 220, 221, 222, 223, 224, 225, 226, 227, 228, 229, 230, 231, 232, 233, 234, 235, 236, 237, 243, 295, 320, 321, 350, 403, 436, 437, 457, 473, 479, 503, 538, 571, 572, 576, 608.	Food Technology: Total 7—Numbers 1, 17, 50, 371, 482, 483, 564.
	Forestry: Total 1—Number 157.
	Genetics: Total 5—Numbers 66, 67, 246, 247, 427.
	Geology: Total 11—Numbers 257, 258, 259, 260, 261, 262, 263, 264, 265, 266, 402.
	History and Government: Total 5—Numbers 107, 248, 249, 250, 251.
	Home Economics Education: Total 4—Numbers 97, 173, 384, 388.
	Horticulture: Total 16—Numbers 63, 119, 120, 121, 122, 123, 341, 366, 367, 368, 369, 370, 371, 482, 483, 564.

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 Industrial Science Research Institute: Total 36—Numbers 20, 25, 26, 73, 75, 76, 77, 79, 80, 129, 130, 131, 132, 133, 134, 135, 136, 137, 138, 139, 140, 141, 142, 143, 144, 145, 162, 166, 241, 242, 305, 306, 307, 308, 385, 386.
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 Institute for Atomic Research: Total 78—Numbers 9, 10, 11, 16, 28, 40, 72, 81, 91, 92, 95, 96, 114, 148, 149, 150, 151, 152, 155, 175, 192, 243, 252, 267, 268, 276, 316, 317, 333, 334, 345, 372, 403, 418, 423, 439, 440, 445, 446, 463, 472, 474, 475, 476, 477, 478, 491, 502, 503, 504, 505, 506, 518, 519, 520, 521, 525, 526, 527, 528, 529, 530, 531, 532, 533, 538, 545, 551, 552, 575, 578, 583, 584, 594, 602, 603, 604, 605.
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 Veterinary Research Institute: Total 8—Numbers 29, 30, 292, 293, 296, 309, 438, 489.

INDEX TO OTHER AGENCIES SPONSORING PUBLICATION

Agricultural Administration: Total 1—Number 554.
 Agricultural Extension Service: Total 5—Numbers 204, 448, 496, 497, 500.
 Agricultural and Home Economics Extension Service: Total 11—Numbers 171, 172, 254, 255, 256, 448, 449, 450, 451, 452, 598.
 Engineering Administration: Total 2—Numbers 516, 517.

General Administration: Total 3—Numbers 314, 315, 397.
 Iowa State College Agricultural Foundation: Total 3—Numbers 579, 580, 581.

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 42. Breed, R. S., joint author. *See under* Buchanan.
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